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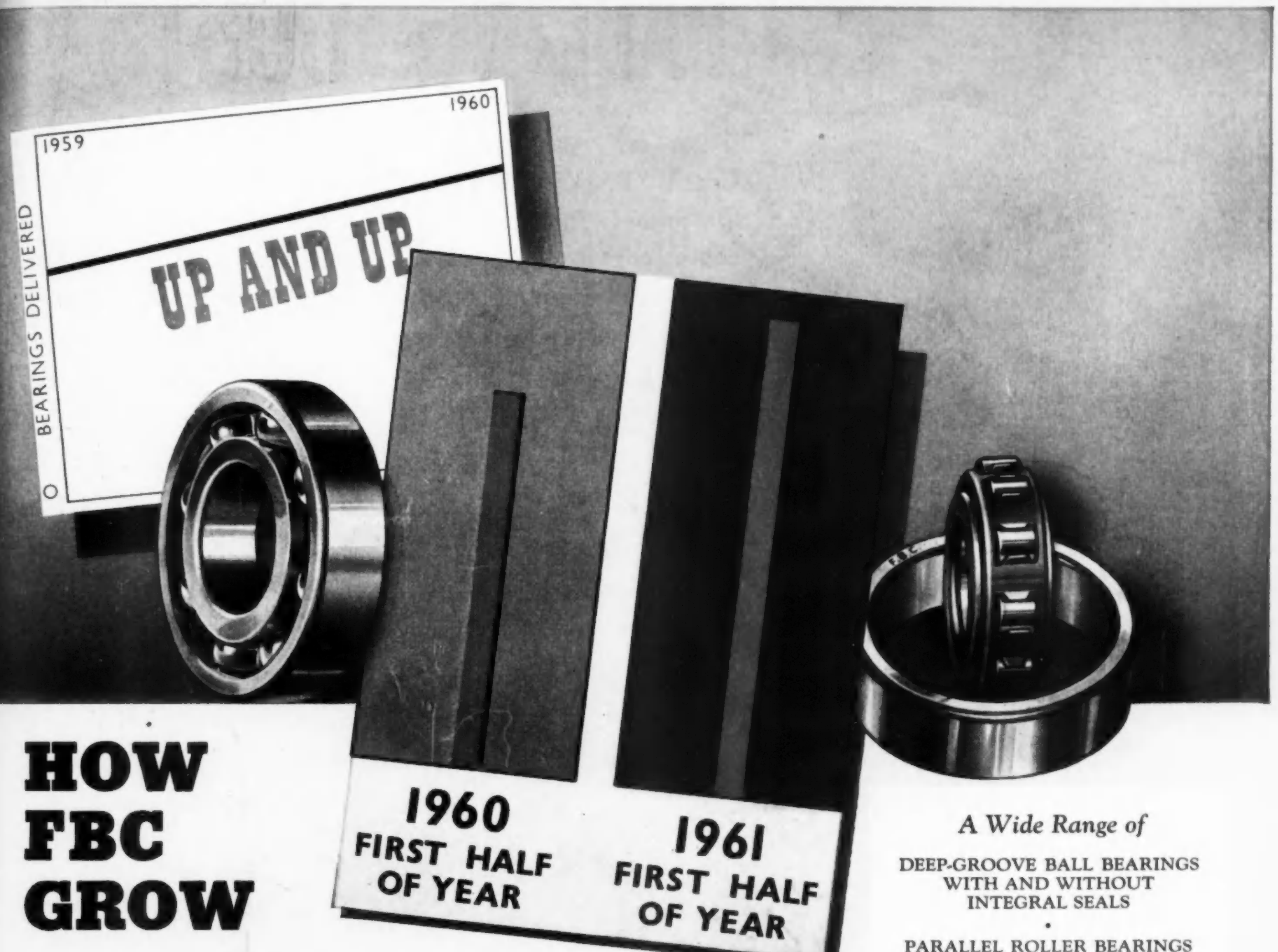

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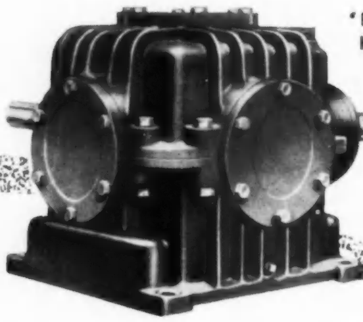

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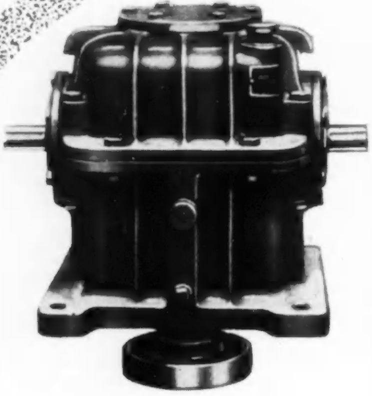

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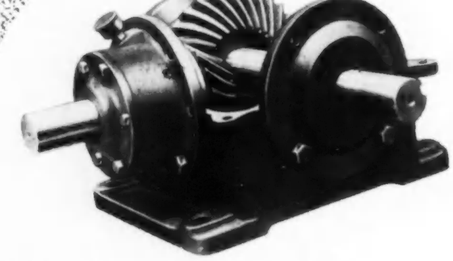

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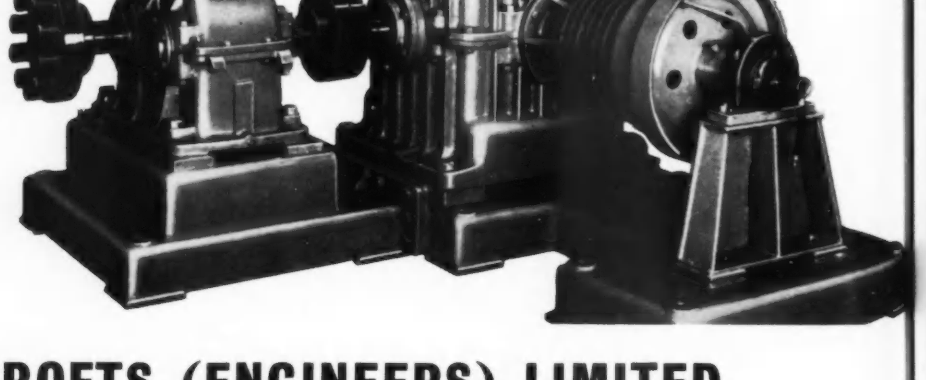

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# THE ENGINEER

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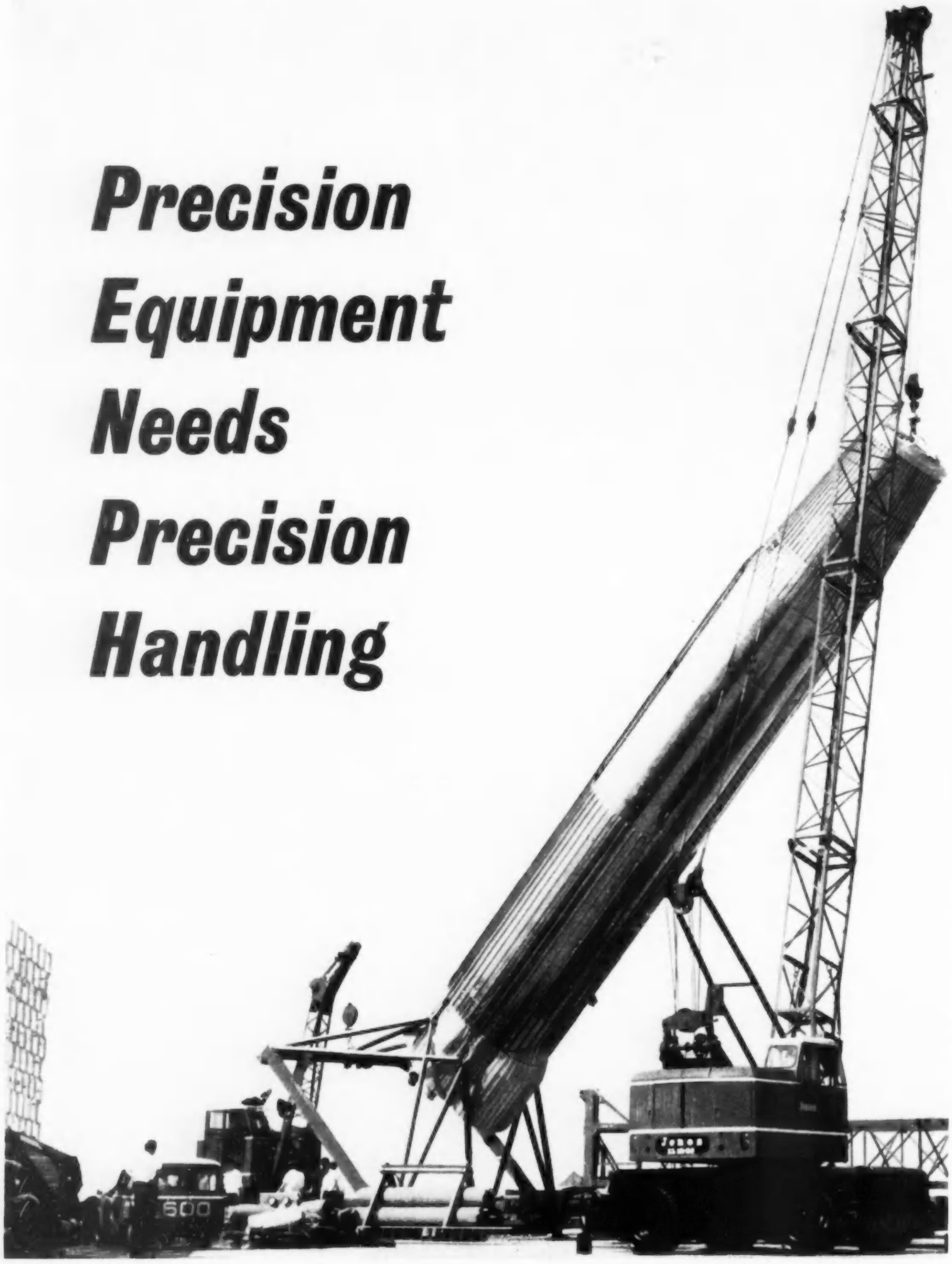

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THE ENGINEER

No. 5526 DECEMBER 22, 1961 Vol. 212

## RAILWAY SPEED

No one travelling on the French Railways to-day can fail to be impressed by the speed, the comfort and the punctuality of the principal express passenger services. Moreover, the speed is unobtrusive. The ordinary visitor to France, travelling, for example, in a train for the South which runs the 195¼ miles from Paris to Dijon in 2½ h, or less, would scarcely believe that for more than three-quarters of the journey the train was running continuously, and without any interruption, at 85 to 90 m.p.h. The engineers of the S.N.C.F. have provided their electric locomotives with power capacity that could be regarded as almost overwhelming. The schedules of express trains running on the various electrified lines are all very fast, but such is the power built into the locomotives that these fast schedules can be maintained with the heaviest loads the traffic authorities see fit to pile on. As Mr. O. S. Nock relates in the article we publish elsewhere in this issue, the effect not only of train loads, but also of gradients, has been virtually eliminated on the S.N.C.F. Our contributor's recent experiences relate to the Northern and South-Eastern Regions, but in the South Western Region, as befits the pioneer French main line electrification — the former P.O.-Midi system — the performance to-day is no whit less excellent. On the South Eastern main line from Paris, the former P.L.M. system, one of the most noticeable features of the running on very fast end-to-end schedules, is the absence of any excessive speed, or isolated "bursts" of energy. It is the steady maintenance of high speed that makes journeys by this route pleasant and restful.

It is inevitable that comparisons should be made with current British performance at a time when standards of speed seem to indicate a tendency to slip back rather than to go forwards, despite all that has already been spent on new forms of motive power. The Eastern Region of British Railways has certainly put into force some welcome accelerations for this winter, including what is now the fastest start-to-stop run in Great Britain — 106·7 miles from Hitchin to Retford in 89 min., at an average speed of 72 m.p.h. But journeys by the faster trains from King's Cross to the north show only too clearly how the running is affected by the numerous permanent speed restrictions *en route*. Except at Peterborough none of these restrictions requires a drastic reduction, but the incidence of lengths where the limit is 70 m.p.h., 60 m.p.h., or slightly less, is a serious handicap on a fast run, and means that powerful locomotives like the new "Deltics" can scarcely settle into their stride, but must be constantly accelerating from one or other of the present "niggling" hindrances. Prior to the modernisation programme now completed the old P.L.M. line in France had many restrictions of a similar kind between Paris, Dijon, Lyons and Avignon. Now every curve and junction has been realigned to permit of steady running throughout at 90 m.p.h., except on some exceptional lengths in the Rhone valley south of Lyons. The re-aligning of a complicated junction to permit of such unrestricted speed can be an expensive item; but in Great Britain many of the intermediate restrictions are in the open country, or at worst through mere wayside stations, where re-alignment should not prove a difficult matter. In the new "Deltics" it is evident that the King's Cross route to the north has motive power capable of equalling the finest French express train schedules — albeit with considerably lighter loads — but the civil engineering restrictions on the line preclude the establishment of any such schedules for the time being.

Elsewhere in Great Britain there are signs that the new power has little in reserve with present-day loads. On the Western Region, for example, there were cogent reasons for a reorganisation of the time-table, and considerable economies in operation are expected from the cutting out of coincident and overlapping services. But it is disconcerting to realise that an increase in load from seven to ten coaches on the "Bristolian", and the insertion of one stop should have needed an increase of nearly 12 per cent on the journey time between London and Bristol. After all, the new diesel hydraulic locomotives were doing nothing more than a job previously worked with complete success by the "Castle" class 4-6-0 steam locomotives of 1923 vintage. On the Anglo-Scottish services by the West Coast route the 2000 h.p. diesel electrics of the "D.200" class are doing excellent work, but they too often seem to be near the limit of their capacity, which on theoretical grounds is considerably less than that of the steam "Pacific" locomotives they have replaced. The heavier trains stop for rear-end banking assistance on the Beattock incline with trailing loads that would not have required any such assistance in the past. South of Carlisle a great deal of extra time has been put into express train schedules to counteract the effect of civil engineering speed restrictions in connection with electrification work. In our recent travelling experience, however, the lengthening of train schedules appears to be out of all proportion to the actual amount of work in progress necessitating reductions in speed. The result is that quite frequently trains are reported on the arrival board at Euston as running 15 min. early, or more, which is just as unsatisfactory as late running.

One cannot help feeling that the conceding of such quantities of extra time is liable to encourage an increasing amount of slackness in working just at a time when everything should be attempted to keep all facets of operation at concert pitch. It is an unfortunate extension of the practice that has grown up since the war of having greatly decelerated schedules for Saturdays in the height of the summer. Why should the service be worsened just at the time when business is at its best? The S.N.C.F. do not relax their tight schedules in the least at their peak traffic periods, when, for example, night expresses for the south are leaving the Gare de Lyon, Paris, at 5 min. intervals for a period of some 2 h, after 7.30 p.m. Still less defensible, in our opinion, is the practice adopted on some routes of British Railways, of lengthening schedules, by "working arrangement," when the load is more than normal. To the ordinary traveller such a train may, for example, arrive at its destination 10 min. late; but because of the increase in load a special timing is in operation and the driver would be credited with an "on-time" arrival! This is nothing more than a concealed way of condoning an inadequacy of motive power. We would agree, that the diesels are sufficient for working a high proportion of the present-day traffic; but for the most part British Railways seem to be setting their sights much too low. We should be looking forward to the time when the journey from London to Leeds, or to Manchester takes no more than 2½ h, and that to Liverpool only a few minutes longer; while an hourly service of electric trains from Euston to Birmingham, making the run in 1½ h, should have ample time for an intermediate stop at Coventry. But even with a revolutionary batch of accelerations like these British Railways would not be up to the best French standard of running.

## MANAGEMENT UNDER THE MICROSCOPE

In some circles it is fashionable to enquire "What is wrong with management?" and having found what appears to be a satisfactory answer, to broadcast it or to use it to "prove" some point or other. Some of those who present papers before the British Institute of Management are not free from this kind of fault. Far fewer people seem interested in finding out what is right with management; no doubt that is less exciting. Of course there are things which can be regarded as either right or wrong about management. But a detailed examination of that question, however objective it may be, cannot, in our view, be of much value. The matter is, in reality comparative; methods of management are not so much right or wrong as better or worse under given conditions. In the circumstances a realistic, and useful, approach, is to try and find out what management really *is*. That is exactly what the Glacier Project (referred to elsewhere in this issue) has been doing for some years. Its work has had many important results, but it is far from finished. Time was, perhaps, when management, if ill-defined or even completely undefined, was at least easy. It may not always have been good management, but its functioning was simple enough. All that was necessary was to decide what had to be done and then see that it *was* done. In its essentials of course, that is the basic function of management to-day, but the former simple concepts of instruction, persuasion, coercion and, if all else failed, the application of *force majeur*, no longer apply. An industrial firm can no longer be run on military lines; perhaps it never could be.

This was well understood by those who initiated the Glacier Project. The simple relationship of master and man, both honestly striving to do his best, often worked well in the days of the small business and does, in the right circumstances, work well even to-day in small firms. But the Glacier Project was concerned with a fast-growing business, in which such a simple relationship was just impossible. So, as it grew, the management examined its own functions as objectively as it could. It has been said that the Glacier Metal management, where the Project was carried out, "took itself to pieces to find out what made it tick", and in doing so it found out a lot of things which had not been realised before. Space does not permit the recording here of even a fraction of the facts discovered by the Glacier Project; several books have, in fact, been written on the subject. What really matters is that a management had the courage to look at itself introspectively and objectively. Naturally, it was not always satisfied with what it found, except in the objective sense that, now it knew what went on, it could take steps to alter, improve or correct it.

The work of the Glacier Project goes on, but it has already found out much that it has put into practice with satisfactory results. Now it is taking its work further by making the results of its studies available, in the form of courses, to managers from other companies. There will be a two-way traffic in ideas, for it has always been the object of the Glacier Project organisers to learn as well as to teach — indeed, learning was its original objective. Anything which can help to raise the standards of the art of management must do good. Those who have the interest of industry generally at heart will wish the new venture well.

## The Engineer—100 Years Ago (DECEMBER 20, 1861)

### THE FIRST STEAM WHISTLE

Tradition has it that following a level-crossing collision between a Leicester and Swannington Railway train and a cartload of eggs and beet, George Stephenson designed the first audible warning device for a locomotive, a form of steam trumpet. But the steam whistle, as it was standardised for locomotives, and as we know it to-day, is older than Stephenson's steam trumpet. Adrian Stephens made a form of steam whistle to sound an alarm when the safety valve of a stationary boiler lifted, and used it at Pentrebach, South Wales, in 1826.

Then in 1833 William Stephens, of Dowlais Ironworks, designed a manually-controlled steam whistle. Thomas Turner, of Manchester, saw the whistle when he was at Dowlais, erecting shafting for his employers, Sharp, Roberts and Company, made a sketch of it and showed it to his foreman, Rose. He in turn passed the idea on to Fyfe, Manchester District Locomotive Superintendent of the Liverpool and Manchester Railway, and the whistle was soon launched on its long career. In 1861 Sharp, Roberts still had Turner's original sketch, and we published an engraving of it, together with a note on its provenance, in our issue of December 20 that year.

# Changing Structure of Engineering Education

By M. C. DE MALHERBE* and A. K. OPPENHEIM†

*On the basis of recent publications the aims of engineering education and its present position at the University level are discussed. The purpose of the education is described in terms of a complete spectrum of the engineer's task from which it appears that there exists a demand for synthesis and design as much as for analysis. Deficiencies of the present structure are critically reviewed, and means for reconstruction suggested. They are based on the recognition of the " Science of Engineering Design " as a fundamental part of the engineer's background.*

THE intense technological progress of our times has exerted strong pressures on engineering education. The initial response to this forcing influence that has been exhibited by academic institutions is, quite naturally, not the best one. Recently the concern over the present situation grew to a considerable extent and the literature became flooded with publications dealing with various aspects of the problem. Judging from them, the evolution, that has taken place so far, over-emphasised the analysis and the so-called " fundamental approach " at the cost of synthesis and " the art of creative engineering." Most of the papers published recently express great anxiety about the damaging effect that this trend may produce on future generations of engineers.

The purpose of this paper is to present an appraisal of the problem, based on a critical survey of recent publications, and to suggest a plausible solution which would satisfy the demands brought about by the professional character of engineering and the requirements imposed by the academic character of the university. The solution is based on the recognition of the " science of engineering design "—the synthesis of the " art of creative design " which is attained by proper application of the fundamentals of logic and decision-making processes and methods to the task of design.

## THE STRUCTURE

The structure of engineering education to-day and the problem that faces its rapid evolution have been described at great length in recent literature. The most significant publications of the last few years are listed here in the bibliography. For the sake of synthesis they have been grouped into sections that deal respectively with : (1) the present structure of engineering education ; (2) the deficiencies and the proposed methods for improvement ; (3) papers that deal explicitly with the subject of design—the core of the problem and the scapegoat of the controversy ; and (4) the more comprehensive publications, elucidating the general aspects and aims of engineering education.

As conveyed by the first group of papers[1·1–1·21] we have at our disposal to-day enough information available to assess the present status of engineering education throughout the world. It appears that the length of time required to obtain a university degree in engineering varies from two to five years, demonstrating in itself a remarkable variety in the approach to the problem exhibited by various universities.

To gain an appreciation of the magnitude of the problem, the break-down of some typical engineering curricula is represented schematically in Fig. 1. It is based on information compiled by Wood [1·20] for his survey of first degree courses in mechanical engineering. Instead of using averages, which would produce a result obscured with indiscriminate statistics, we have selected only a few universities from Wood's compilation, as the most representative of their kind. The curriculum of each is depicted by a block made up of three parts. The lowest gives the total number of hours of instruction devoted to the fundamental sciences, that is, mathematics, physics, chemistry, mechanics, thermodynamics, &c. The upper part indicates the amount of time allotted to the elements of design. The remaining portion is that taken by engineering applications and specialised subjects.

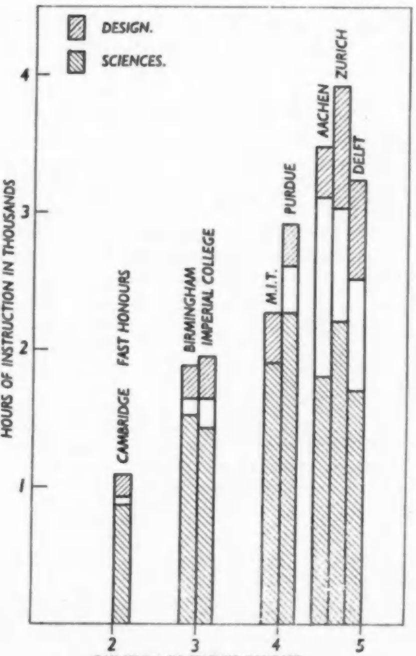

Fig. 1—Breakdown of engineering curricula

The shortest duration of studies is that of the British system which emphasises the acquisition of bare fundamentals, without the possibility of instilling in the student any professional attitudes and techniques. The graduates of this type of an education have to undergo a post-graduate apprenticeship in industry, generally of two years' duration, in order to acquire the status of a professional engineer.

The longest period of time represents the tradition of technical universities on the continent whose aim is to develop a fully qualified engineer capable of taking up, upon the receipt of his diploma, a responsible position in industry.

The impact of the rapid expansion in technology that occurred over the last decade has been much stronger of course on the curricula of shorter duration where relatively greater modification had to be introduced in order to meet the demand for engineers capable of coping with new technologies. Curricula of longer duration provided more flexibility for the absorption of the additional burden. Hence the adjustment of the educational system that has been taking place in the form of an evolution on the Continent and in Russia, acquired a revolutionary character in Great Britain and in the United States. Consequently, in the English-speaking world, the opinion that " the function of universities is the teaching of analysis "[1·19] (page 427), has grown considerably in strength, and the teaching of design and of the so-called " creative engineering " has been almost annihilated.

The situation became quite critical and seemed to have reached a climax as demonstrated by a number of conferences devoted to the problem of engineering education (e.g. the International Conference on Scientific and Engineering Education at M.I.T. and the meeting on "Engineering Education in the Year 2000 A.D." at McGill University) and by the great flood of papers over the last four years that discuss the deficiencies of the present structure and suggest various means of corrective measures.[2·4–2·20] The critics seem to agree on one point only, namely, that the undergraduate education should be as broad as possible, common to many disciplines for the first two years, leaving the specialisation to more advanced studies.

The victim of the revolution is the subject of design.[3·1–3·14] The attempts to annihilate it produced the strongest reaction both from practising engineers as well as educators. It is significant to note that a few months ago THE ENGINEER received three articles from Great Britain, [3·3] Switzerland [3·7] and Australia,[3·5] voicing great concern about this problem. The protagonists of " creative design " emphasised that without due consideration given to the subject of design, engineering education may perish altogether.

In the appraisal of the present state of affairs we are helped by comprehensive publications[4·1–4·7] which provide information on the historical background, the logistical approach and the philosophy of engineering education.

## THE FOUNDATION

The anxiety about the deficiency of engineering instruction to meet the challenge of technological progress is by no means new. It has been quite prominent ever since the beginning of the technological age.[4·1] To gain a proper perspective on the present situation let us then examine briefly under what form this problem has manifested itself in our generation.

At first the progress of aeronautics has been reflected in the growths of aerodynamics that revolutionised the subject of hydraulics. It provided a rational approach to fluid mechanics which eventually affected the whole field of mechanics. Then radio became a technical reality, and a corresponding evolution affected the field of electrical engineering, leading to the great expansion of the subject of electronics. The advent of reinforced and prestressed concrete provided a similar stimulus to the field of civil engineering and produced the subject of structures, as we know it to-day.

---

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As a result there has been a growing demand since the nineteen-thirties for the adoption of a rational approach to engineering and the introduction of more sciences into engineering education. It was advocated then that this could be accomplished by increasing the emphasis on analytical subjects and reducing the large load of empirical information and professional techniques which overloaded the curricula at that time. In the nineteen-forties these demands were gradually met by university authorities who in many cases came to the conclusion that the most proficient way to make engineering more scientific is simply to appoint scientists to engineering faculties. As a consequence of these tendencies, we have witnessed in the nineteen-fifties the gradual elimination of design. It appears now that the pendulum has swung the other way, and new demands are being raised, this time for the re-establishment of design but, of course, in a more rational form than before.[2.20]

### SCIENCE AND ENGINEERING

Since the most prominent aspect of the problem facing the evolution of engineering education is the controversy between science and engineering, the exact nature of the difference between them must be clearly understood.

The best clarification that the authors have come across among the many recorded in the literature is that given in the 1959 Report of the M.I.T. Committee on Engineering Education.[3.14] According to this report :

" Simply stated science implies a body of knowledge and a scientist is one who professes to a part of this knowledge. The scientist is primarily concerned with discovering, codifying and understanding the nature of the physical world, of searching out similarities, of making generalisations by means of which natural phenomena may be predicted. He seeks to solve problems which have definite answers. His output is primarily information.

" The goal of the engineer is to utilise the knowledge of the physical world for social benefit. In order to achieve this end he designs and builds physical objects, devices, structures, processes and systems. The problems which he seeks to solve have many possible answers from which he must select an appropriate solution.

" The scientist's problem is to discover truth, the engineer's to determine a course of action."

The difference between the scientists and the engineers is elucidated further in the report of the Curriculum Study Committee of the University of California, Los Angeles [2.16] as follows :

" The scientist has never been in doubt where he stands. To him the discovery of laws of nature is the sole and the ultimate aim of science."[‡] Furthermore " values are deliberately excluded from the purview of natural sciences " while " values are not only deliberately included in engineering " but also " figure prominently in any statement of an engineering problem " because " the aim of engineering is to optimise the usefulness (i.e. values) of resources to man."[§]

Thus, " the determination of the stress field in the bar of metal is not of itself an engineering problem. The determination of the proper design of structure to withstand a load at minimum cost or weight and/or deflection is an engineering problem." It is of interest to note that the former involves the use of analysis, while the latter is attained as a result of synthesis.

Of particular significance to us is the opinion on the difference between the role played by the engineer and the scientist in the evolution of mankind, and its influences on education, that has been given by Sir Hugh Taylor[4.6], a distinguished physical chemist. To make his point, he quotes in turn Michael Polanyi, a physicist and philosopher, who stated that " the knowledge of physics and chemistry is ancillary to the knowledge and understanding of operational principles " which are identified with the science of pure engineering. " Our acceptance of this view of engineering science in its relation to physics and chemistry," concludes Sir Hugh Taylor, " has important consequences in our attitude towards engineering education. Engineering science on this view operates at a higher level of reality in the inanimate world than do physics and chemistry." This distinction between the two levels is based on the views expressed by Polanyi according to whom the study of inanimate objects " constitutes the science of physics and chemistry and the study of machines forms the sciences of engineering." leading him to the general conclusion " that the subject matter of engineering cannot be specified in terms of physics and chemistry."

### THE ENGINEER'S TASK

In order to develop a rational approach to the evolution of education one has to have a clear view of the task facing an engineer with a university degree. A great deal has been written on this subject and a great number of definitions, examples and illustrative problems are available in the literature.[2.3, 2.7, 2.13, 2.15] For the sake of clarity and at a certain risk of over-simplification, we have summarised the salient features of the engineer's task in the block diagram (Fig. 2).

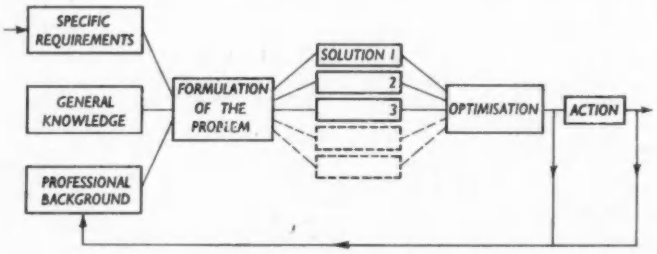

Fig. 2—Block diagram of the engineering task

The job is generally specified in terms of requirements which are given as input. On this basis, with the general knowledge which he must acquire and the professional background that he must possess, the engineer has to arrive first at a comprehensive formulation of the problem in the engineering sense. As a rule the problem is never completely defined. One is always faced with an inadequacy of information and consequently the existence of more than one solution appears on the diagram. The consideration of a number of solutions is in fact a characteristic property of an engineering problem, and should not be overlooked, as it often is, at the university and in practice.

The final solution is attained as a result of a process of optimisation—the necessary condition for a proper engineering product. An engineer's task is incomplete without a course of action that leads to the final output in the form of the product. Of particular importance also are the feed-back lines which originate from the solution, before and throughout the course of action, and provide the necessary ingredient of experience for the professional background.

To illustrate the significance of the diagram let us consider a specific example, for instance that which Dean Tribus[||] likes to give his freshmen students in order to describe the task they are likely to face after graduation. He confronts them for this purpose with the problem of establishing a communication system for a newly formed government in Africa.

" To make the problem more specific, suppose you have joined the United Nations as an engineer, and have been sent to country X in Africa and on arrival are asked to take the responsibility for setting up a communication system which will enable the newly-formed Government to keep in touch with the outlying districts.

" A host of questions will immediately come to mind. Who will use this system ? What kind of messages will be sent ? How many places must be reached ? What budget limitations must be met ? It is the designer's responsibility to see that these questions are answered. It is idle to expect someone else to take this responsibility, simply because no one else knows what questions to ask ! Only the designer, who knows what is possible through the application of to-day's science and technology, can raise the significant questions. The answers to these questions come from many places, from the Treasury of the U.N., from sociologists or anthropologists, from the Government representatives, and from the natives themselves. Every bit of evidence tends to reduce the uncertainty, to narrow the choice, to make certain systems impossible, and to make others more attractive."

He concludes by emphasising that, if we are to accept the responsibility as designers, we must accept also the uncertainty which comes with the task. " Only in the most trivial situations do we begin a design with sufficient information at hand to see it to the end," he claims. " Indeed such designs are called obsolete for they have been tailor-made usually to other circumstances. Whenever an old design can be used there is no need for an engineer ; at least not in that portion of the problem."

The above example deals only with the formulation of the problem, but it points out clearly the desired method of approach to other parts of the task. Not every graduate engineer will be called upon to tackle the whole job himself, but he should have a clear view of the complete spectrum of the task. By the same token he gains appreciation of the significance of each elementary operation from the overall point of view, which the technicians and other workers engaged in the same enterprise do not possess. In particular he is expected to know how to collect the information that will give him a satisfactory grasp of the situation, and how to derive from it an engineering formulation of the problem, just as much as to know how to solve it by analysis and design—the traditional core of the engineer's job.

Processes that involve synthesis are clearly depicted on the block diagram of Fig. 2.

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[‡] H. Le Chatelier, *Science et Industrie*, Flammarion, Paris, 1925.

[§] Julian Huxley, *Man in the Modern World*, Mentor Book, 1956.

[||] Tribus, Myron, School of Engineering, Dartmouth College, Hanover, N.H., U.S.A., personal communication.

They are denoted there simply by converging flow lines. Significantly enough they correspond also to those stages of the task that involve decision. Two such stages are evident : the first concerned with the formulation of the problem, and the second with the attainment of the optimum solution. And it is the ability to tackle adequately these two aspects of the task that distinguishes an engineer with a university degree from others.

### THE PROBLEM

From the point of view of the engineer's task, described in the previous section, the knowledge provided by our universities appears quite inadequate. The only fragment to which the student is sufficiently exposed is that which permits him to tackle singular solutions of well-defined problems. The essential ingredients of attitudes and judgements which are necessary for the formulation of the problem and for the optimisation leading to final solution are usually neglected.

Furthermore, the protagonists of the so-called " fundamental approach " are advocating solely the acquisition of analytical knowledge with a complete neglect of design, providing the student only with the ability to analyse existing solutions and quenching his creative traits. The protagonists of design on the other hand, restrict themselves unduly to " know-how," treating it as an art rather than a science and over-exposing the students to the time-consuming and wasteful process of " pushing the pencil " or " filing a piece of metal." The engineering departments that over-emphasise analysis face the danger of losing completely their engineering identity and becoming eventually second class departments of physics, while those who cling to the tradition of design may find themselves completely outside the scope of the university.

As a result of these two conflicting forces the structure of engineering education at the universities is beginning to show some definite signs of cracks, indicating the necessity for reconstruction. This should be based on the recommendation suggested by von Karman [2·20] as follows :

" The way to proceed from theory to practical conclusions has to be taught in school and this is a hard task. . . . . To solve this problem is the main task of our engineering colleges and only the solution of this problem can stop the trend among our young students away from engineering towards science."

### THE RECONSTRUCTION

The essence of the problem that faces engineering education is how to modify it in order to meet the challenge of rapidly expanding technology and to satisfy at the same time the academic requirement of a scholarly pursuit of knowledge upon which the university quite rightly insists.

The background for a rational approach to the solution has been given by the M.I.T. Committee[3·14] in the following words :

" The ostensible content of an engineering education is a body of knowledge and a set of skills which enable a student to solve engineering problems. It is clear that education is much more than this. Whether consciously taught or not, students acquire attitudes and habits as well as information and techniques. . . . Certain specific attitudes are required to make effective engineers and engineering schools cannot escape the responsibility for the attitudes as well as the knowledge and skill of their students."

The U.C.L.A. Committee[2·16] specifies furthermore that :

" Engineering education must provide knowledge and understanding, as well as stimulus to use knowledge, in all areas of human endeavour pertaining to the aim of engineering.

" These are :

" *(a)* In engineering : its specific approach to the solution of problems involving values and resources.

" *(b)* In science : its principles and laws, its methods and techniques.

" *(c)* In humanities : the background for and the issues behind the values."

The solution is conditioned by the premise that the university, being an academic institution, rather than a professional school, has to concentrate upon fundamentals, leaving the acquisition of skills and techniques to other resources, such as industrial experience and specialised training. The only fundamental subjects, however, that have gained universal recognition to-day are those of analytical nature. Their scope has to be therefore broadened to include the subjects that equip the students with a rational approach to design.

What are they ? Considering the full scope of the engineer's task, presented in Fig. 2, it appears that the additional fundamental knowledge that an engineer must possess is in the area of synthesis and the decision-making processes. The rational approach to design should therefore be developed from basic disciplines for such operations.

Interestingly enough the fundamental subjects needed for this purpose stem from pure, rather than applied mathematics, namely from mathematical logic, topology, and the theory of groups and sets, that form the so-called " elementary mathematics."[2·17] The required modification of the curriculum should then involve an introduction to these disciplines as well as to the derived subjects of the probability theory, the theory of games and the fundamentals of statistics and economics as the elements of the decision-making processes and their application to design.

It is the proper consideration of these subjects that provides the rational basis for the " Science of Engineering Design," the recognition of which by the university forms, in our opinion, the essence of the solution.

Our conclusion leads to an incongruous outcome that, at the time when the curricula are already overcrowded, their scope has to be further enlarged. Obviously this cannot be accomplished without a certain amount of surgery which is always a painful process.

For a rational approach to design of a curriculum under such circumstances the U.C.L.A. Committee[2·16] recommends the principle that : " The most interesting facts are those which can be used several times, those which have a chance of recurring."¶ The Committee then points out that consequently :

" In establishing the hierarchy of values science attaches a greater value to a law or principle which has wider application, which affects more of its fields, and explains not only more facts but a greater variety of them. In like manner we must give preference in the engineering curriculum to those subjects and methods of inquiry which are common to most, if not all, engineering activities. They are more general and therefore their power of prediction carries farther into the future. To the surprise of no one they are also closer to the fountainhead of science."

Logical consequences of the above principles are given here insofar as they affect, respectively, the undergraduate curriculum, the postgraduate studies, and the university faculty.

*Undergraduate curriculum.*—On the undergraduate level the curriculum should be built up in three phases. The first, common to all the professional disciplines of engineering, should contain, besides the introduction to analysis as it is done now, the fundamentals of synthesis given by the " elementary mathematics " and the theory of probability, augmented by elements of descriptive geometry to develop in the students the ability of three-dimensional thinking—the necessary requirement for design.

The second phase should stress the acquisition of the knowledge and a certain amount of proficiency. This would be largely based on the development of the " Science of Engineering Design," that is, a rational approach to the design problem governed by the process of synthesis. As is appropriate for the academic institution, the acquisition of proficiency at this phase should be based not so much on " know-how " as on " know-why "; that is, not on the encyclopaedic knowledge of the handbook type of information, but on the fundamental considerations that lead to technological practice.

In the third phase the student should be exposed to some experience in an actual, real design activity which would permit him to combine the knowledge of analytical disciplines and those of synthesis, that he acquired earlier, with the design task.

The " Science of Engineering Design " would thus form an over-arching element, cutting across individual disciplines of the curriculum, and giving it a more unified character. By concentrating upon a realistic situation to which the student would be exposed in the third phase of his undergraduate studies, the university would help considerably in the development of resourcefulness—one of the most important ingredients of a creative engineer, which has been so badly neglected in the school-type curricula prevalent at our academic institutions.

*Post-graduate studies.*—On the post-graduate level proper consideration should be given to the complete engineering task presented in Fig. 2.

So far the programme of post-graduate studies at our engineering colleges has followed primarily the lines developed at the departments of science, most emphasis being given to the type of research that provides information. Although such an activity is most appropriate to the scholarly atmosphere of a university, it does not reflect adequately the full scope of the engineer's task. As a result of it, the post-graduate research at our universities has become solely one of service either to industry or to other sciences.

Modern technological demands place, however, responsibility on the university for the development of resourceful, proficient engineers and competent leaders for large engineering projects. This aim could be attained only by a post-graduate activity that would involve tasks of larger scope than those at present contemplated in academic institutions. Although the government and industry sponsorship of post-graduate research at the university is to-day a well established practice, it seems that it follows the well-known adage of George Bernard Shaw, " He who knows, does ; he who doesn't, teaches," for the engineering departments of our colleges have seldom been entrusted with a responsibility in an engineering project of national importance.

The recognition of the science of engineering design would be greatly aided by engaging the university itself as an active participant in an ambitious research and development project that would involve the design and manufacture of a novel technological product. This in fact has been—and still is—the case in government sponsored research in physics but, paradoxically enough, a similar pattern has not been followed in engineering.

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¶ H. Poincaré *Science and Method*, Dover Publication.

The situation is obscured still more by such classical paradoxes as the achievement of one of the greatest engineering feats of our times, the process of controlled fission, by Fermi, a theoretical physicist, and the fact that to-day one of the most challenging problems in theoretical physics, the control of fusion, is in principle engineering in nature, for it is concerned with the control of a known phenomenon whose discovery has culminated in the explosion of the hydrogen bomb.

To-day the fact that large engineering projects require more resources than those that can be provided by a single company is so well established, that the tackling of such projects by a team of companies has become a prevalent practice. The capacity of the engineering department of the university should be recognised as a valuable asset to such teams. Some isolated instances of precedents to such a scheme are known, including cases when the university was not only a partner but even a manager of an industrial team. If, then, instead of the practice of haphazard consulting by university professors, a team made up of professors and their graduate students was adopted as a partner in an industrial project, the benefits to all parties concerned would indeed be great. For the university it would provide the contact with reality, without which graduate studies become so much devoid of the engineering element ; to the students it would give a valuable experience in team work and the possibility of a critical insight into a large enterprise which is quite difficult to obtain by a young engineer ; and to the industry it would supply talent and young blood so important to the future of any technological development.

*Faculty.*—On the faculty level it is universally agreed that the teaching of engineering at the university should become more scientific. This principle received quite an enthusiastic recognition by university authorities and in many instances it led to the appointment of scientists to engineering faculties. Although admittedly quite beneficial at first, this influx of educators who have not had sufficient exposure to the whole spectrum of the engineering task begins to show some negative results. Many of our graduates become completely lost when faced with engineering reality with which they had so little contact during their studies. Since, moreover, most of our graduates are equipped primarily with the knowledge of analytical procedures, they quite naturally prefer the sheltered life of research to the more exposed adventure in creative engineering. The complaints of industry about the lack of competent designers with a suitable scientific background have been voiced on many occasions, but so far little has been done about this problem by our universities. It would indeed be quite beneficial to the university, and of considerable importance to future engineering generations, if it were recognised that the success of an engineering college must be based on the scientifically minded engineer rather than the engineering minded scientist.

## CONCLUSIONS

To meet the challenge of the technological progress of our times the evolution of the educational system for engineers should be directed along the following lines :

1. The " Science of Engineering Design " should be given at least an equal recognition to analytical sciences in the university curriculum for engineers.
2. On the undergraduate level the evolution should be based on the introduction of subjects fostering the " Science of Engineering Design " and providing a rational background for design. The design should be treated as an indispensable part of the curriculum in order to integrate the analysis and synthesis into a unified methodology for tackling the engineering task.
3. On the post-graduate level the evolution should be enhanced by ambitious research and development projects dealing with the whole spectrum of the engineering task rather than its single elements. With proper support from government and co-operation with industry such projects would provide means for the interchange of ideas across various disciplines of engineering sciences, broaden the scope of activity of the graduate school and give it the invaluable experience in teamwork—the salient condition for modern technological progress.
4. On the faculty level more attention should be paid to the development of the science of engineering by engineers, who have proper understanding of the whole spectrum of the engineering task, than to the development of engineering sciences by the scientists, who are versed only in some specific areas of applied science.

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**TRANSISTOR FOR V.H.F. AMPLIFICATION.**—A new low noise germanium alloy-diffused transistor, developed specifically for amplification of frequencies up to 200 Mc/s, is available from Mullard Ltd., Mullard House, Torrington Place, London, W.C.1. Noise figure is only 6dB at 200 Mc/s and power gain in the common emitter mode is greater than 10dB. Although particularly suitable for radio-frequency circuits in v.h.f. communications equipment, the stability of this AFZ12 transistor enables it to be used in a variety of video and other broad-band high frequency applications. Dimensions in TO-18 encapsulation are 5·3mm long by 4·8mm diameter. An inter-lead shield connected to the metal case is provided.

# Appleby-Frodingham Universal Beam Mill

*Rolling of steel beams with parallel or near-parallel flanges first became possible in 1902, when Henry Grey designed a four-roll universal mill which was installed in Luxembourg. Since then beam mills of the universal type have been installed in various parts of the world, notably in Germany and the U.S.A. and, more recently, in Great Britain. There have been many developments in the last few years, and one of the latest universal beam mills to be built, at the Scunthorpe Works of the Appleby-Frodingham Steel Company (a branch of the United Steel Companies Ltd.) has several novel features. The article which follows (see colour plates on page 1042) is based on information supplied by Herr Josef Wurm, of Schloemann A.G., and the Appleby-Frodingham Steel Company.*

ADVANCED structural steelwork techniques have brought about a marked increase in the demand for beam sections with parallel flanges. Because of their particularly favourable ratio of deadweight to modulus of section, wide-flange beams and universal columns with parallel flanges are being employed to an increasing extent in the construction of multi-storey buildings and bridges. As the webs and flanges of the beams and columns can easily be rolled to various thicknesses the range of applications of the rolled products is very wide, and their use, already greatly increased, is likely to develop rapidly.

When Appleby-Frodingham decided to instal universal beam rolling equipment, it was specified that the mill should operate in conjunction with an existing 32in three-stand heavy section mill, and that it should roll universal wide-flange beams from 8in by 5¼in to 24in by 9in and universal columns from 6in by 6in to 12in by 12in. It was also required that the installation of the new mill should involve no more than nominal interruption of production from the existing heavy section mill. To meet these requirements the designer and constructor of the new mill, Schloemann Aktiengesellschaft, Dusseldorf, Germany, worked in close co-operation with the Appleby-Frodingham engineering staff, and with the Distington Engineering Company Ltd. (a United Steel subsidiary), which manufactured the mechanical parts of the mill (Fig. 1).

In the planning stages several possible alternatives were investigated. These are illustrated diagrammatically in Fig. 4. The ideal solution from the capital costs aspect, if it was decided to employ only a single, universal group of stands (main stand and edger), with no provision for subsequent plant extension, is shown in Fig. 4 (*a*). In Fig. 4 (*b*) the ideal solution on the basis of capital costs, with provision for the subsequent installation of a universal finishing stand, is shown. Fig. 4 (*c*) shows the best solution from the technical viewpoint, if it was proposed to employ one universal group of stands, and make no provision for subsequent extension. Finally, Fig. 4 (*d*) shows the best solution technically if a universal group of stands and a finishing stand were to be installed in a single extension programme.

In all the possible schemes, shown by Figs. 4 (*a*) to 4 (*d*) inclusive, it would have been necessary to put out of service, at intervals, the existing saw line serving the 32in section mill, while the new mill was erected. This was undesirable; consequently, a new scheme was evolved to obviate this requirement. The new proposal, Fig. 4 (*e*), provided for the material to be transferred, in full lengths, direct to the cooling-bed roller table. This makes it possible for the conventional heavy-section mill to operate independently, if required, or to serve as a roughing mill feeding the universal beam mill stands. These latter comprise main and edging stands in which the shaping of the beam or column is done in a series of passes, and a finishing stand in which a single finishing pass is taken.

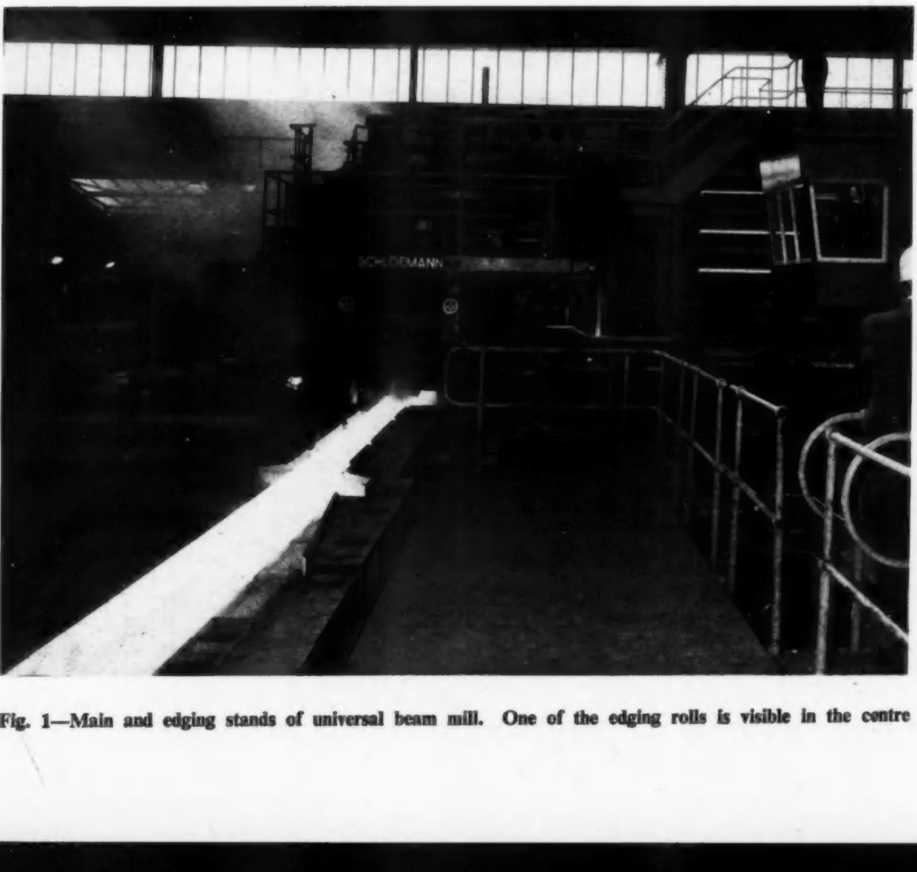


**Fig. 1—Main and edging stands of universal beam mill. One of the edging rolls is visible in the centre**

## OPERATION

The operation of the existing and new mills as a production unit can be explained by taking a typical rolling procedure for a 14in by 6¾in wide flange beam with parallel flanges. An existing 42in blooming mill provides material in the form of a 13½in square bloom, which can be fed to the 32in section mill or by-passed to a reheating furnace, as required. This bloom is reduced in nine passes in the 32in mill to a rough beam shape. It is then delivered by skid transfer to the universal beam mill. Here it is given four passes in the roughing group stands and one finishing pass in the universal finishing stand, from which it emerges finish-rolled to size and shape. Fig. 2 shows the sequence of rolling passes diagrammatically, from the final pass in the 32in mill to the finished piece of the size stated. Other sizes may require a different number of passes in the roughing group, but the overall sequence of operations would be the same. After rolling in the finishing stand of the universal mill, the beam is moved laterally by a lifting transfer bank to the hot saw line of the 32in mill.

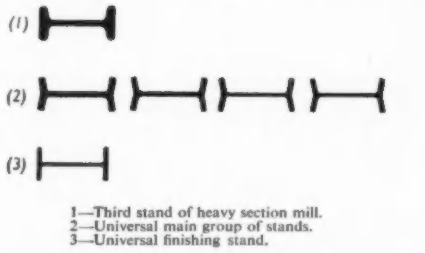

(1)
(2)
(3)
1—Third stand of heavy section mill.
2—Universal main group of stands.
3—Universal finishing stand.

**Fig. 2—Sequence of passes when rolling wide flange beams with parallel flanges**

The skid transfer taking the rough pieces from the 32in mill to the universal mill is located between the universal group of stands and the universal finishing stand. Thus, fairly long intervals between initial passes are necessary, as a new piece cannot

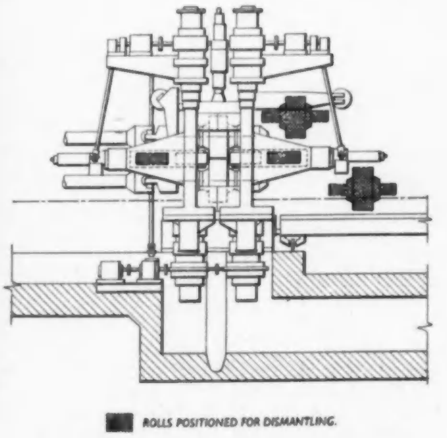
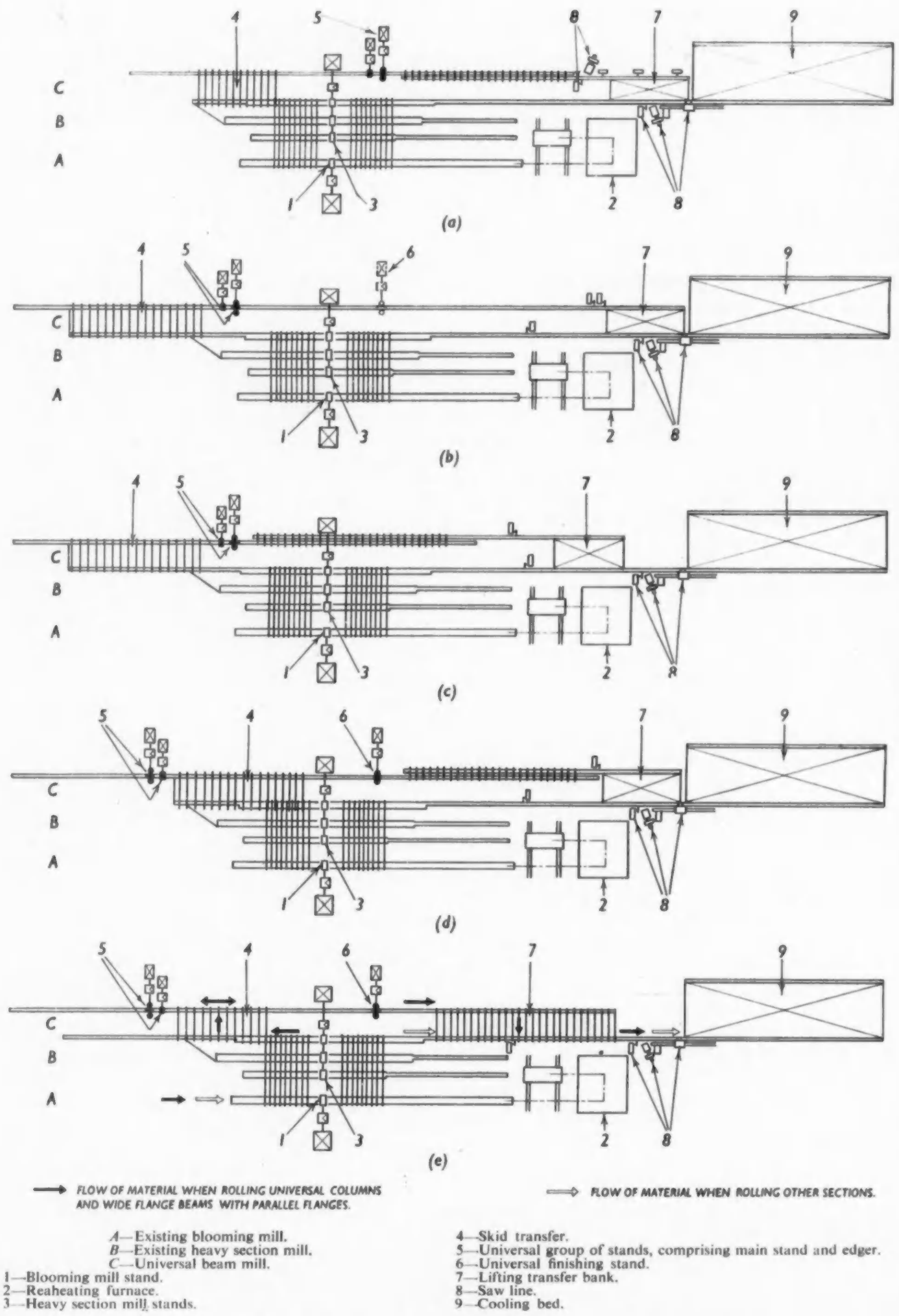


**Fig. 3—Arrangement of universal main and finishing stands**


(a)
(b)
(c)
(d)
(e)
A
B
C
1
2
3
4
5
6
7
8
9
FLOW OF MATERIAL WHEN ROLLING UNIVERSAL COLUMNS AND WIDE FLANGE BEAMS WITH PARALLEL FLANGES.
FLOW OF MATERIAL WHEN ROLLING OTHER SECTIONS.

A—Existing blooming mill.
B—Existing heavy section mill.
C—Universal beam mill.
1—Blooming mill stand.
2—Reheating furnace.
3—Heavy section mill stands.
4—Skid transfer.
5—Universal group of stands, comprising main stand and edger.
6—Universal finishing stand.
7—Lifting transfer bank.
8—Saw line.
9—Cooling bed.

**Fig. 4—Possible layouts of universal mill stands in relation to existing heavy section mill**

be entered until the previous one has left the run-out table in the range of the skid transfer. However, this layout made it possible to instal the new plant with a minimum amount of alteration to the existing equipment, and without any appreciable stoppages of production at the 32in mill. There is a distance of about 40ft to be covered by the skid transfer, which has to operate as quickly as possible to prevent undue loss of heat in the piece.

### UNIVERSAL MILL STANDS

The main and finishing stands are of the same design and dimensions (Fig. 3), though the finishing stand drive is of lower horsepower. This arrangement allows for considerable economies in the stocking of spare parts. The horizontal rolls are nominally 50in diameter and have a barrel-length of up to 24in ; the vertical rolls are of 38in nominal diameter, with a barrel length of 15in. On the main stand the horizontal rolls are designed to have tapered flanks, the taper being up to 5½ deg., to suit the particular beam being rolled. The working faces of the vertical rolls on this stand are vee-shaped with a double 5 deg. taper. On the edging stand the roll flanks may be tapered by up to 7 deg., depending on the mill schedule. The flanks of the finishing stand horizontal rolls have a slight taper of about ¼ deg., while the vertical rolls are cylindrical. Fig. 5 shows how the rolls are arranged in the three stands. Through the addition of separate, additional chocks for the vertical rolls, the horizontal rolls can be dressed down by about 17 per cent. Accurate side adjustment of the horizontal rolls is provided for by means of screw-operated window panels.

All the rolls are mounted in roller bearings. The frames for the vertical rolls are cast integral with the horizontal roll housings. This robust closed-housing design was chosen to provide the rigidity necessary for rolling to close tolerances, even when producing light section beams with parallel flanges. Both the horizontal and the vertical rolls are hydraulically counterbalanced, and they are provided with motorised individual or synchronised screw-down. In order to obtain a constant rolling plane or pass line, the top and bottom horizontal rolls must be adjusted at a uniform rate, corresponding to the pass reduction. This synchronisation can be effected electrically, or by mechanical connection of the two motors for top and bottom rolls ; in this installation the mechanical method is employed. A central hydraulic system, with a capacity of 22 gallons and a pressure of 995 lb per square inch, provides the working fluid for the roll counterbalances. Cooling is by water from the works mains. Load cells are used for measuring the rolling load in the chock assemblies of the vertical and the top horizontal rolls, the meters being mounted on the desk in the control pulpit.

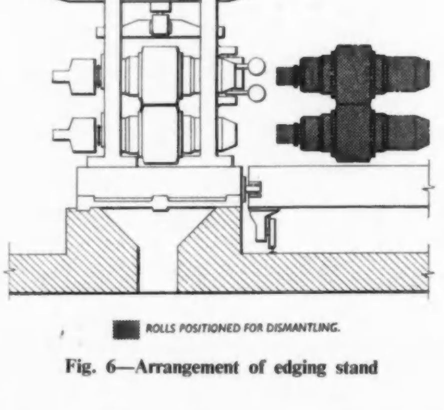


**Fig. 6—Arrangement of edging stand**

The third item in the group of stands comprising the universal mill is the edging

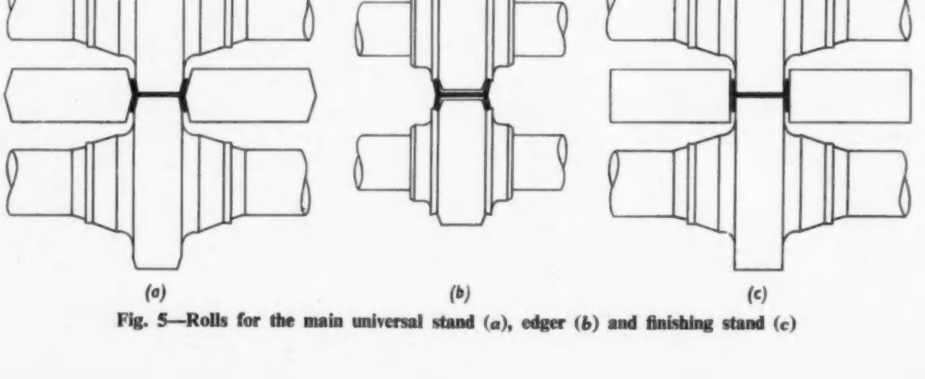

(a) (b) (c)

**Fig. 5—Rolls for the main universal stand (a), edger (b) and finishing stand (c)**

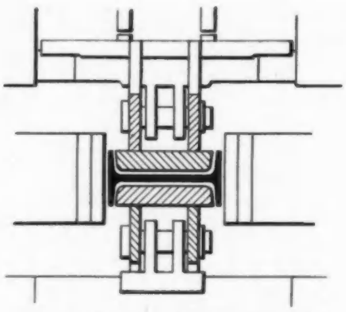


Fig. 7—Stock guides at roll stands

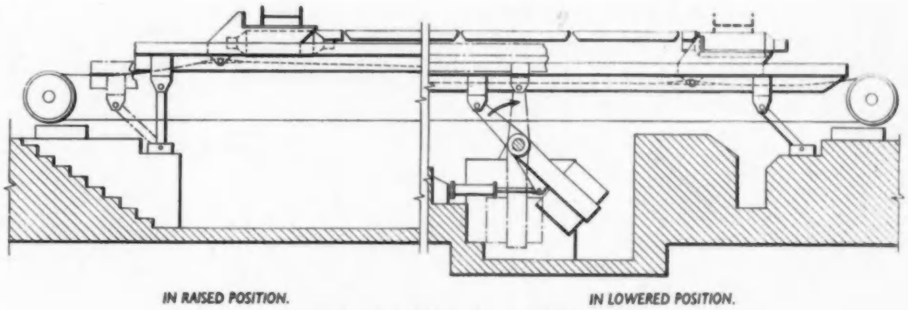


Fig. 8—Lifting transfer bank

stand (Fig. 6). This is located close to the main stand and on the entry side of it. This ensures that oncoming stock from the final stand of the 32in mill is positively entered in the universal stand, the rolls of the edging stand acting as pinch rolls to feed the universal rolls. The location of the edging stand at this point has the further advantage that the last edging pass is given immediately before the piece leaves to enter the finishing stand, and this ensures square edges on the section.

The edging stand has 36in nominal diameter rolls, mounted in a closed-top housing and provided with a duplex roll-changing rig for easy changing. The top roll is hydraulically counterbalanced and provided with motor-driven screw-down gear. Spacers fitted between the withdrawal carriage and the chocks enable the variation in the height of dressed-down rolls to be compensated. Screw-operated panels provide for axial positioning of the rolls.

### ROLL CHANGING

In designing the roll stands, particular attention was given to the provision of quick roll-change facilities, and the stands are so arranged that each roll can be withdrawn individually (Figs. 4 and 6). Each time a different beam size is to be rolled the horizontal rolls have to be changed, whereas the vertical rolls normally need changing only when dressing is necessary. For this reason the design allows the horizontal rolls to be changed readily without removing the vertical rolls. The top horizontal roll is withdrawn with the aid of an overhead runway built on to the mill housing, and the bottom roll is moved out on a screw-propelled traversing carriage. It is also possible to change the vertical rolls independently of the horizontal ones. When a roll change has to be made, the vertical roll on the free side of the stand (that is, on the side opposite to the drive), is run into the retracted position and picked up by the crane. After the upper spindle has been swung out sideways, the vertical roll on the drive side is removed in a similar manner. The vertical roll housings are designed for quick and simple roll changing. Both universal stands and the edger are equipped with duplex roll-changing rigs, which are identical to facilitate the stocking of spare parts.

When the shaped blanks are being rolled to beams with parallel flanges they are guided on the web and the insides of the flanges. Specially-designed guides, as shown in Fig. 7, are provided for this purpose. To ensure accurate entering for the initial pass the piece, which is first gripped by the horizontal rolls of the edging stand, is positioned by adjustable water-cooled side guards on the approach table. During its transfer from the edging to the main stand the piece is guided from above and below by guide shoes. Similar guide shoes are mounted immediately in front of and behind

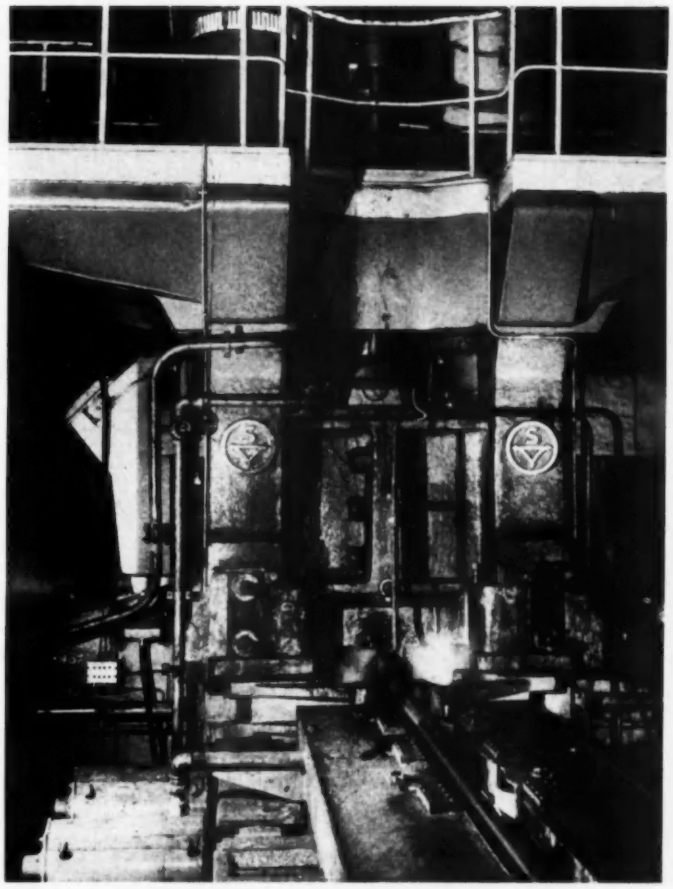


Fig. 9—Ingoing side of universal finishing mill

SCHLOEMANN

Fig. 10—Outgoing side of universal finishing mill

all the stands to ensure positive guidance of the piece. Lateral guides are fitted between the vertical and horizontal rolls in the main and finishing stands. These guides, which also serve as counterbalances for the vertical rolls, are supported by the vertical roll chocks, with which they are adjusted.

Between the guides are mounted the strippers for the vertical rolls. These do not actually make contact with the rolls, and the small clearance is adjustable. This small clearance prevents, on the one hand, ingress of scale into the chock and, on the other hand, allows the large volume of sprayed cooling water to escape. Suitable strippers are also provided for the horizontal rolls, and for the rolls of the edging stand. The rest bars, to which the guides and strippers are fixed, are of rugged steel construction. They are secured on the outside of the housings, and can be adjusted both horizontally and vertically. The stripper and guides can be changed without disturbing the rest bars.

### Drive and Control

The main electrical equipment was supplied by the English Electric Company Ltd. A 5500 h.p. reversible motor, with a speed range of 0/60/150 r.p.m., drives the main universal stand and a 1500 h.p. motor, with a speed range of 0/110/275 r.p.m., drives the edger. The motors of both stands are fed by cross-connected rectifiers, this arrangement being particularly suitable for simultaneous rolling of the piece in the two stands, on account of its favourable control characteristics. Rolling speeds in the edging stand and main stand are matched to suit the pass reduction and rolling direction, and in order to obviate the need for constant speed changing by the operator, they are programmed for both stands and preset, together with the incremental adjustments to the screw-down between passes. In action, the mill operator sets the speed of the main stand and the rotational direction, and the edging stand is controlled simultaneously in accordance with the selected speed ratio.

Screw-down of the horizontal rolls of the main stand and of the edger rolls is by 25 h.p. d.c. motors and that of the vertical rolls is by a 15 h.p. d.c. motor. All screw-downs have Ward-Leonard control. Both the horizontal and the vertical rolls can be adjusted individually or collectively. Accuracy of screw-down is ±0·004in. A programme control provides for the preselection of screw-down values for up to eight passes. These values are set on two control panels, so while one size of beam is being rolled the panel can be set for the next size to be rolled. All the programmed values set can be cancelled by means of a push-button. The absolute value and the deviation from the nominal value are shown continuously by indicators in the control pulpit.

A 2500 h.p. motor, with a speed range of 0/60/150 r.p.m., drives the finishing stand, and motors identical with those on the main stand drive the screw-downs. No programme control is required, as only one pass is given in the finishing stand, and the screw-down is adjusted only when the mill schedule is changed. The finishing stand can be operated automatically, using photocells mounted adjacent to the roller table which control the mill entry table and mill motor speed. Should the piece fail to enter the mill the table rollers and mill reverse automatically, and re-entry is attempted. This sequence will continue, in case of further failure to enter the rolls, until stopped by the main stand operator.

### Roller Tables and Transfer Gear

All roller tables are individually driven. The tables on the front and back sides of the roughing group stands are d.c. motor-driven and Ward-Leonard-controlled. The remainder are driven by a.c. variable-speed floating motors fed from variable low-frequency converters. All the motors were made by Laurence, Scott and Electromotors Ltd., Norwich. At the approach and run-out sides of the main and edger stands are several rollers mounted individually on an adjustable frame, enabling the table surface to be adjusted to suit the depth of the material handled, and so to maintain a constant pass line.

Transfer of the finish-rolled beams and columns from the run-out roller table of the finishing stand to the saw line and cooling bank of the 32in mill is by means of a transfer bank equipped with carriages or " monkeys " (Fig. 8), designed to prevent damage to the flanges of the rolled sections, which are still hot at this point. These carriages are positioned in line with the finishing mill run-out table, and when a beam or column is over the carriages, the tracks on which the carriages run lift, allowing the product to be transferred laterally to the saw line of the 32in mill, where cutting to length is carried out. From the saw the finished products go forward to the existing cooling bank and dispatch facilities.

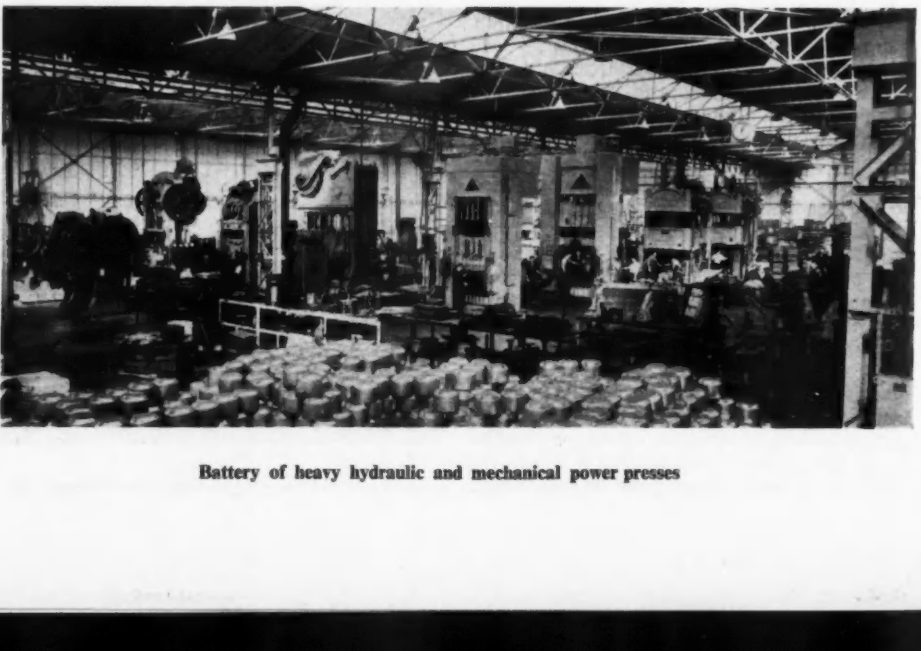
The civil engineering work on the site was not excessive, and involved demolition and rebuilding on a new site of an existing mill office, in addition to the foundation work for the new machinery. This work was done by Holst and Co., under the direction of the Appleby-Frodingham civil engineering staff, the whole of the concrete being made with Appleby-Frodingham slag aggregate—the company's normal practice. Mill lubrication is from two centralised systems housed in two cellars, one near the main stand and the other near the finishing stand. Duplicate control panels for both systems are mounted in each cellar, and complete control of the lubrication equipment can be exercised by one man.

Scale disposal from the mills has also received special attention. Instead of the conventional water flush to primary settling pits, which are cleared at intervals by crane grab, the scale is flushed to a conical sump where initial quick settlement is achieved by tangential entry, giving a cyclone effect. A totally-immersed pump at the bottom of the cone clears the scale to a conventional scale pit, and the partly-clarified water is pumped through a battery of Dorr-Oliver " Hydroclones." Part of the clear water from this battery is returned to the mill stands for roll cooling ; the remainder is sand filtered and then used for general mill purposes.

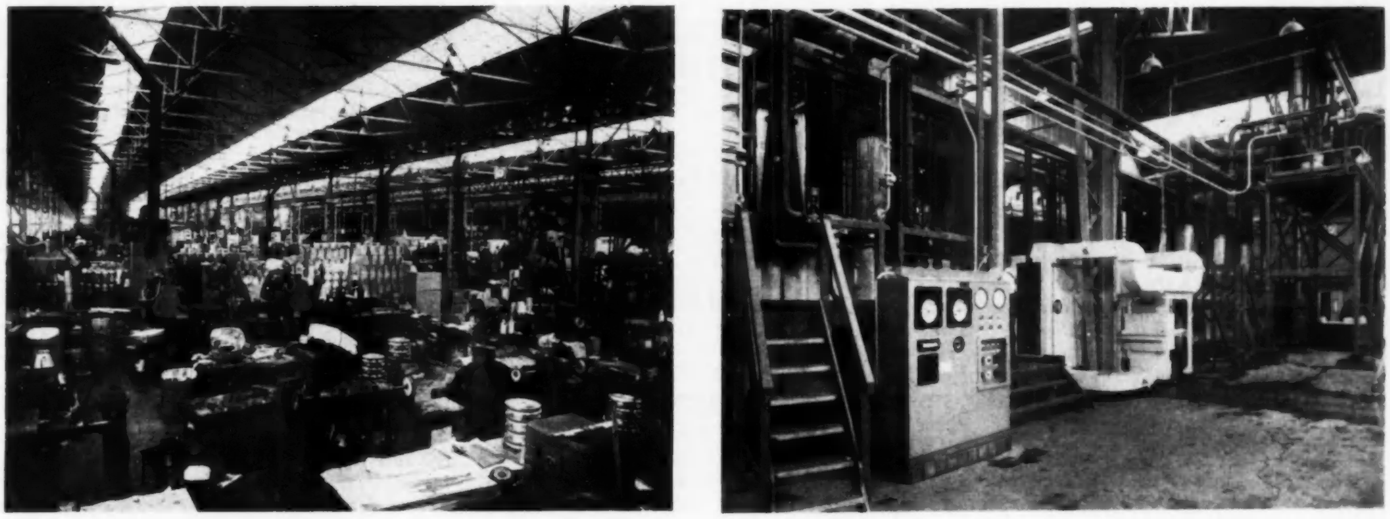
# Sheet Metal Factory at Wombourn

*Limitations imposed by the space available in its Birmingham factories upon expansion and reorganisation decided the London Aluminium Company Ltd. to build a new works to allow for the introduction of additional plant and to plan an efficient pattern of work flow. The new factory is located at Wombourn near Wolverhampton.*

WITHIN a few years of the economic production of aluminium the London Aluminium Company Ltd. was founded in London by the British Aluminium Company Ltd. with the object of establishing applications and developing markets for the metal it was producing. The start in 1897 was modest, but as the potential of the new light metal was slowly appreciated, business expanded sufficiently to justify a removal to more commodious premises and by the beginning of the first world war the Westwood Road factory was in full production. War time requirements kept the company fully employed and in the years which followed production continued to expand and a sound export trade was established. During the second world war the works was engaged on a wide variety of equipment in light alloy and in the post war years, with the rapid expansion of the use of light alloys for industrial and domestic applications, manufacturing space, despite the acquiitions of additional premises, was soon at a premium. This lack of space and the corollary that it was impossible to reorganise production in conformity with modern methods, resulted in the decision to seek a new factory site. This was eventually found on the Bridgnorth Road at Wombourn near Wolverhampton. A site of twenty acres was required and a 600ft long Coseley multi-crane bay



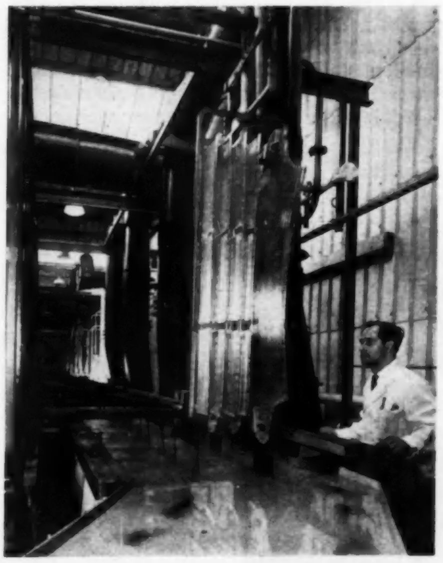
**Battery of heavy hydraulic and mechanical power presses**



(Left)—Polishing bay and the larger spinning machine to the right. (Right)—View of loading side of automatic chemical polishing and anodising plant

factory building erected consisting of three 60ft span bays together with a 20ft lean-to, and a self-contained anodic shop. An " L "-shaped two-storey air conditioned office block was also erected on the site. The factory has a floor area of about 140,000 square feet and the site provides adequate room for expansion. The move to Wombourn has permitted the careful planning of the shop floor so that there is an efficient pattern of work flow resulting in the minimum of materials handling. The company manufacture a wide range of products for an equally wide range of industries so that provision has had to be made for a variety of operations involving close production control. This has been achieved by placing executive offices along one side of the building so that there is close contact between the shop floor and control.

As well as moving equipment from the Birmingham factory the company added new plant including six presses of 350 to 500 tons capacity. These include a 500-ton four point press with a slide and bolster 108in wide, an 84in wide 300-ton press supplied by the Scottish Machine Tool Corporation Ltd., and other presses of Fritz Muller manufacture. Some of the presses can be seen in our illustration. Altogether there are more than forty presses ranging from the mechanical power units, having a bed size of up to 108in by 72in and a stroke of 18in, down to small hand-operated presses. Mechanical safety guards are fitted but some units are equipped with an electronic eye system which, upon any interruption of the ray, stops the stroke of the press. There is a spinning and flow forming section which ranges from items produced by a metal spinner's art to a machine for spinning large paraboloid radar reflectors having a diameter up to 15ft and a spinning depth of 2ft 6in. There is also a multi-station automatic polishing line, and plans are in hand for the introduction of further automation in order to strengthen the competitive position against the possible entry of Great Britain into the Common Market. Items for the electrical, textile, dairy, bakery, chemical, pharmaceutical, food, and motor car industries &c., are among the diverse products of the factory. One of the company's important products is a range of motor car trim items, and it was the realisation of the potential for brightened and anodised aluminium which decided the company to develop the " Brytal " finish and to develop components for the motor car industry. Investigations were made into other methods of brightening and into the availability of suitable brightening aluminium alloys and as a result the new factory incorporates an automatic chemical polishing and anodising plant which uses the " Phosbrite " process. This process permits the use of lower priced alloys and by reason of quantity production of constant quality pieces costs are competitive. The plant, installed by Albright and Wilson (Mfg.) Ltd., is 78ft long by 12ft 6in wide by 16ft 6in high and provides finishing processes for aluminium automobile trim, consisting of " Phosbrite 159" chemical polishing and sulphuric acid anodising, coupled with the necessary pre-and-after-treatments. We include a general view of the loading side of the plant and also illustrate chemically polished and anodised radiator grilles leaving the multi-station anodising plant. The equipment is designed for large-scale production and the output may be varied by a process timer which can be set to give an immersion time at any station of from zero to five minutes. Basic tank dimensions at the station are 78in deep by 32in wide and the machine has a lift of 71in, sufficient to allow radiator grilles five feet long to be treated in the vertical position. After the trim components have been loaded on to jigs these are transferred at the loading station to carriers, which are at a spacing of 3ft, ready to begin the treatment cycle. This commences with three individual stages of alkali soak, for degreasing, followed by : a cold water rinse, desmudging in nitric acid, and a hot water rinse. The pieces are then chemically polished in " Phosbrite 159," at 100 to 105 deg. Cent. and over a period ranging from 0·5 to 3 minutes, the process being under fine control by means of a delayed set down mechanism, and then rinsed in water at 60 to 70 deg. Cent. to remove the film. Desmudging in nitric acid is followed by two cold water rinses before anodising at a current density of 14A per square foot. There follow two cold water rinses, a hot water sealing stage and a final drying in hot air before unloading the carrier.



Chemically polished and anodised radiator grilles prior to rinsing and hot water sealing

Consideration of the process materials used and the need for a maximum operational life decided the use of stainless steel for the chemical polishing tank, the nitric acid desmudging tanks and the hot water rinsing tanks, while P.V.C. or lead is used to line the cold water rinse tanks. Steel, rubber-lined, forms the anodising tank which has fitted lead cathodes. P.V.C. fume removal ducting and hoods are fitted except at the hot water sealing stage where stainless steel hoods are employed. Aluminium busbars carry the d.c. anodising current and are fed from a rectifier which is housed together with a transformer and switch gear in a separate room. Remote control is from a panel in the instrumentation control cabinet near the loading and unloading point. The temperature of the anodising bath is thermostatically maintained by controlling the flow of chilled water through high efficiency graphite block heat exchangers. Multiple inlet points ensure the even distribution of the returning acid. In addition to the set down control at the "Phosbrite 159" tank there is equipment for mechanically oscillating the work over a small amplitude to ensure uniform polishing. To economise on water supplies a recirculation system has been incorporated in the effluent plant and 75 per cent of the water consumption is treated and returned to the anodising shop for further use. There is a well-equipped laboratory for research and control including accelerated testing of aluminium trims against atmospheric attack in which 100 hours is equivalent to between ten to fifteen years' service. Heating of the works is by oil-fired air heaters supplied by Harris Engineering Company Ltd., and Danks of Netherton Ltd. provided the steam-raising plant. The main contractors were Sir Alfred McAlpine and Sons Ltd.

# Recent Express Train Running in France

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E., M.I.Loco.E.

No. I

*The electrification of certain sections of the Northern Region of the S.N.C.F. on the 25kV a.c. system at 50 cycles per second renders the train working of particular interest to British observers in view of the modernisation work now in progress on British Railways. At the same time the standards of performance regularly achieved with the earlier electrifications in France at 1500V d.c. are probably the highest anywhere in the world. In this article and its sequel the author describes some recent experiences with both systems of traction.*

NOT many weeks ago the present author was discussing with a French railway *littérateur* of international reputation some of the recent locomotive work on the S.N.C.F., and he remarked quite casually : " Oh yes ; we have eliminated loads and gradients." And one must admit that when trains of 500 tons are taken up gradients of 1 in 200 at sustained speeds of 86 to 88 m.p.h. there is ample truth in the contention. This particular performance was noted in the course of a journey with one of the ordinary English boat trains between Paris and Amiens, and is apparently nothing much out of the ordinary with the modern 25kV electric locomotives now working on the Northern Region of the S.N.C.F. Before describing in detail the running on four recent journeys between Paris and Amiens some reference is needed to the locomotives, which are of two types both with the $B_0$-$B_0$ wheel arrangement.

The " BB16,000 " series is designed for express passenger service, while the " BB16,500 " series has a variable gear ratio, enabling the locomotives to be used in passenger or freight service as required. The principal characteristics of these two designs are set out in the accompanying Table I. In both types the electrical transmission between the high-voltage, single-phase, a.c. supply and the d.c. traction motors is through a transformer and two pairs of 10in diameter ignitron rectifiers.

TABLE I—*S.N.C.F. Nord Region : 25,000V A.C. Locomotives*

| Series | BB16,000 | BB16,500 | |
|---|---|---|---|
| Class of service | Express passenger | Passenger | Freight |
| Horsepower, continuous rating | 4920 at 53 m.p.h. | 3500 at 51 m.p.h. | 3500 at 30 m.p.h. |
| Corresponding tractive effort | 15·2 tons | 11 tons | 18·8 tons |
| Maximum tractive effort | 32·2 tons | 19 tons | 32 tons |
| Maximum speed | 100 m.p.h. | 87 m.p.h. | 53 m.p.h. |
| Total weight | 84·5 tons | 66 tons | |
| Traction motors | Four bogie suspended motors (rectified) d.c. (920V, 1040A) | Two motors, bogie suspended (rectified) d.c. (1100V, 1250A) | |

The express locomotives of series " BB16,000," (Fig. 1) specially designed for high speed running, embody the fruits of experience gained with earlier French electric locomotives. The mechanical part is based upon that of the " BB9200 " 1500V d.c. locomotives which have proved so remarkably successful in operating the very heavy and fast express services of the South Eastern Region of the S.N.C.F. The bogies are without centre pivot and follow the Alsthom swinging pivot system. The motors are suspended in the centre of each bogie, and are geared for a maximum speed of 100 m.p.h. The design of the pantographs is specially suited to high-speed running. They are > shaped, instead of the more usual lozenge form of construction. An interesting feature of the mixed traffic locomotives of the " BB16,500 " series is the arrangement for changing the gear ratio, which enables either of two gear ratios to be selected by the movement of a lever in the side vestibule of the locomotive. The gear change can be made only when the locomotive is at rest, suitable interlocks being provided to guard against inadvertent misuse. The final drive, through a large gear meshing with pinions on each road-wheel axle, results in a bogie with an unusually short wheelbase of only 5ft 3¼in. Despite this, excellent stability in running has been secured by use of the Alsthom swinging pivot system of bogie mounting, and in passenger service these locomotives have a maximum speed of 87 m.p.h.

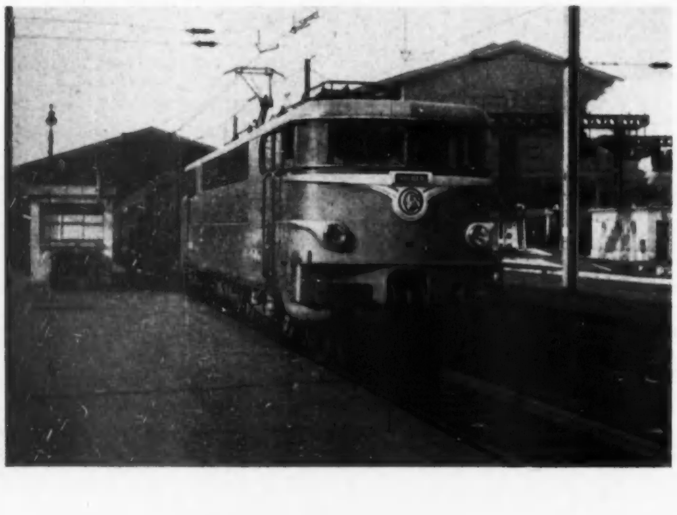


**Fig. 1—25,000V, a.c., 50 cycles locomotive of " BB16,000 " series at Paris, Gare du Nord**

Coming now to the actual runs, the two journeys southbound from Amiens to Paris were made with relatively light loads, one at a time of light traffic at the commencement of the summer season, and the other on a duplicate portion of the " Golden Arrow," conveying only through carriages for the south not needing to be worked into the Gare du Nord at Paris itself. The gradient profile between Amiens and Paris can be broadly described as two gables, one contained in the 50 miles between Amiens and Creil, and having no gradients steeper than 1 in 250, and the second, with long continuous ascents of 1 in 200 on each side of the summit, in the 27½ miles between Creil and St. Denis. Apart from a speed restriction to 90 km.p.h. (55 m.p.h.) through Creil, trains can be run up to the maximum speed for the line, 87 m.p.h., throughout. The powerful " BB16,000 " class locomotive had a very easy task on the first run with a load of no more than 350 tons, but it was interesting to have one of the mixed traffic units on the second journey. Both trains were running strictly on time.

TABLE II—*S.N.C.F. Nord Region : Amiens–Paris*

| Run No. | | 1 | 2 |
|---|---|---|---|
| Locomotive No. | | BB16012 | BB16570 |
| Locomotive type | | " Express " | " Mixed-traffic " |
| Loads, tons gross (trailing) | | 350 | 375 |
| Distance, miles | | Time, min. sec. | Time, min. sec. |
| 0·0 | Amiens | 0 00 | 0 00 |
| 2·9 | Longueau | 4 22 | 4 08 |
| 27·0 | Gannes | 21 19 | 22 37 |
| 47·5 | Laigneville | 35 43 | 38 33 |
| 49·9 | Creil | 38 05 | 40 50 |
| | | p.w. checks | p.w. checks |
| 62·7 | Survilliers | 61 25 | 60 24 |
| | | checks | — |
| 77·4 | St. Denis | 74 27 | 71 58 |
| 81·2 | Paris, Nord | 80 05 | To Paris Lyon |
| Average speed : | | | |
| Uphill, Longueau–Gannes | | 85·2 m.p.h. | 78·2 m.p.h. |
| Downhill, Gannes–Laigneville | | 85·4 m.p.h. | 77·2 m.p.h. |

Table II shows the logs of the two journeys and the striking uniformity of the speed, uphill and downhill, between Amiens and Creil will be particularly noted. On both occasions civil engineering work on the line caused severe delays on the uphill section between Creil and Survilliers. The express locomotive No. BB.16012 was stopped for 3 min. prior to entering a section where single line working was in operation, and from Survilliers the train was routed via the relief line, and no higher speed than 77 m.p.h. was attained during the descent to St. Denis. Nevertheless, as will be seen from the log, the journey from Amiens to Paris was completed at an average speed of 60 m.p.h. despite these severe hindrances. The mixed traffic locomotive, on run No. 2, regained speed rapidly after Creil, accelerating to 77½ m.p.h. up the 1 in 200 gradient past Chantilly. Then a long length of restricted speed followed, which on the basis of previous performance cost some 9½ min. in running. The former level of speed was quickly recovered afterwards and the downhill stretch from Survilliers to St. Denis was run at an average speed of 76·7 m.p.h. The net time to passing St. Denis was about 62½ min., representing an average speed of almost 75 m.p.h. from the start.

This performance on the part of the relatively light mixed traffic locomotive, having a weight of only 66 tons, was certainly a very good one, but it represents a mere fraction of the maximum capacity of the class. On the bank between Creil and Chantilly, climbing 1 in 200, at 77 m.p.h. the equivalent drawbar horsepower was between 1900 and 2000, representing a drawbar pull of 4 tons to 4½ tons. Yet the continuous rating of these locomotives, as will be seen from Table I, at 51 m.p.h. provides a tractive effort of no less than 11 tons. It is probable that equally fast running could have been made with a train of roughly double the load. The capacity of the express passenger locomotives of the "BB16,000" series was more seriously tested on the second of the two northbound runs from Paris detailed in Table III, on which a trailing load of 515 tons was conveyed. Both these northbound runs were made on the 7.54 a.m. service, though the first was on a duplicate portion of the train.

TABLE III—*S.N.C.F. Nord Region: Paris–Amiens*

| | | | |
|---|---|---|---|
| Run No. ... ... ... ... ... | | 1 | 2 |
| Locomotive No. ... ... ... | | BB16009 | BB16011 |
| Load tons gross trailing ... ... | | 410 | 515 |
| Distance, miles | | Time<br>min. sec. | Time<br>min. sec. |
| 0·0 | Paris, Nord ... ... | 0 00 | 0 00 |
| 3·8 | St. Denis ... ... ... | 5 38 | 5 47 |
| 6·3 | Pierrefitte ... ... ... | 7 35 | 7 48 |
| 18·5 | Survilliers... ... ... | 16 08 | 16 27 |
| | | p.w. checks | p.w. checks. |
| 31·3 | Creil ... ... ... ... | 29 37 | 28 35 |
| 33·7 | Laigneville ... ... | 31 53 | 31 24 |
| 45·2 | Avrechy ... ... ... | 40 05 | 40 09 |
| | | p.w. checks | — |
| 54·2 | Gannes ... ... ... | 53 09 | 46 50 |
| 69·0 | Ailly-sur-Noye... ... | 63 25 | 57 14 |
| | | p.w. checks | — |
| 78·3 | Longueau... ... ... | 71 36 | 64 01 |
| 81·2 | Amiens ... ... ... | 76 32 | 67 37 |
| Average speeds: | | | |
| Uphill, Pierrefitte–Survilliers | | 85·8 | 84·7 |
| Uphill, Laigneville–Avrechy | | 84·2 | 79·3 |
| Downhill, Gannes–Ailly ... | | 86·5 | — |
| Downhill, Gannes–Longueau | | — | 84·2 |

No more than a glance at the average speeds at the foot of Table III is sufficient to show that the present maximum speed for the line was being run, or closely approached wherever possible, both uphill and downhill. The relative absence of checks on the second journey resulted in a fine start-to-stop average, inclusive of the one slowing for permanent way work, of 72·2 m.p.h. from Paris to Amiens, with a trailing load of 515 tons. On this journey the maximum effort occurred soon after the start, when on the 1 in 200 bank leading to Survilliers speed rose to 86 m.p.h. on the gradient. This represents an equivalent drawbar horsepower of about 3100, though not by any means the maximum of which these remarkable locomotives are capable. From the passengers' point of view the steady, even speed maintained, the quietness, and the exceptional smoothness of the riding are especially noteworthy. There are no more than a few short stretches between Paris and Amiens where the condition of the track is not quite up to the very high standards now prevalent in France, but these few exceptions merely served to emphasise the excellence of the travelling as a whole. The Northern Region of the S.N.C.F. is in any case a railway in transition; to see the full effects of modernisation in France one must travel by the former P.L.M. line to Lyons and the south, and some journeys on very heavy electrically-hauled express trains will be described.

(*To be concluded*)

# Production of Cans from Precoated Aluminium Strip

*To reduce production costs of aluminium cans Aluminium Laboratories Ltd. has developed a method of manufacturing double-drawn cans from pre-lacquered aluminium strip. This is produced in a continuous anodising and lacquering plant built by Alcan Industries Ltd.*

ALTHOUGH the aluminium food can offers a number of advantages, economics have prevented its wider adoption in this country, the main element in its higher cost being that of providing interior protection. To-date, this has involved spray lacquering or anodising after production, involving the installation of degreasing plant and equipment for applying and stoving the lacquer and for batch anodising. In an endeavour to reduce costs to a more competitive level Aluminium Laboratories Ltd. has been engaged in the development of a method of producing double drawn cans using pre-lacquered aluminium strip. A prototype canning line was designed to produce size 211 by 205 (6 oz) cylindrical cans, having a length/diameter ratio of 1 to 1, from lacquered coil. Further, it was decided that the cans should undergo processing without the use of super pressure autoclaves so that an aluminium alloy combining adequate strength and drawing characteristics was required, and the material selected to satisfy these requirements was Noral M.57S.½H. (B.S. 1470: NS4½H) having a thickness of 0·012in. For the production of the cans it is essential that the adhesion properties of the lacquer should be adequate to withstand the forming operations and Alcan Industries Ltd. has equipment at Rogerstone to produce lacquered strip known as "Anolac" which meets this specification.

We recently had the opportunity of seeing this prototype canning line which we illustrate and which consists of two 60-ton mechanical presses, operating at ninety strokes per minute, linked by belt conveyor. In the press on the right of our illustration, circles are blanked from "Anolac" strip 6in wide and drawn into a cup representing a reduction of 44 per cent at this stage. The cup is transferred by belt conveyors to the second press, where it is drawn to its final size, with a 24 per cent reduction, embossed, flanged and trimmed in one operation.

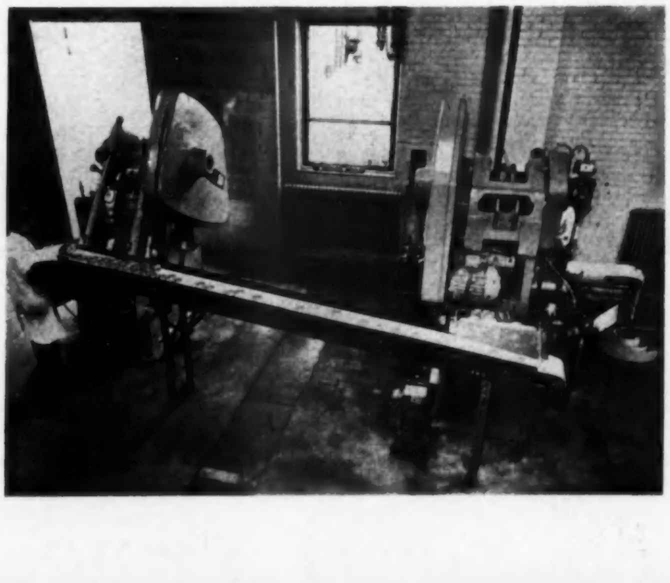
After ejection from the press the cans pass over a grid through which the "shred" falls. Apart from a few special tools the presses and most of the auxiliary equipment are standard and the line costs about £7000. The new production system, which eliminates degreassing and lacquering after forming, has, it is claimed, reduced the cost by about 15 per cent, and although the cost of three-piece tinplate cans is considerably lower the capital cost of equipment for the aluminium can is very much less.

Associated with the production problems were the packing tests and the establishment of the shelf life of cans filled with a variety of low acid foods of 5 to 7 pH. For these tests the cans were packed under normal commercial conditions and stored at room temperature (68 deg. Fah.) and also at 95 deg. Fah., at which temperature the rate of hydrogen liberation is increased so that the tests are accelerated—nevertheless tests at room temperature are considered as being more reliable. The results of the tests show that the shelf life equals or exceeds commercial requirements and that magnesium-free alloys as well as those containing magnesium are satisfactory.

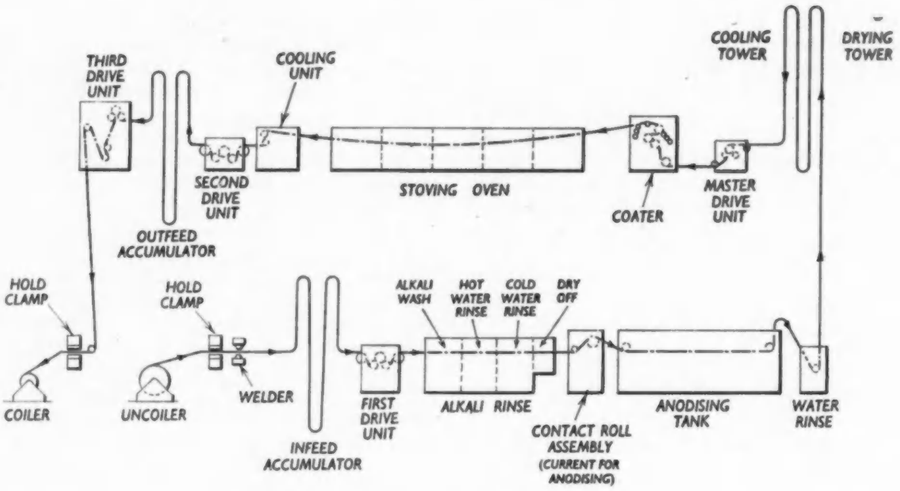
### ANODISED AND LACQUERED STRIP

The can manufacturing operations require lacquers that are flexible to a high degree and offer a similar degree of adhesion. Such anodised and lacquered material is now being produced at the Rogerstone works of Alcan Industries Ltd. and it is expected that the plant will be in full production early in 1962, and will have an annual capacity of 4000 tons per annum. The continuous anodising and lacquering line at Rogerstone has been developed to apply lacquer, as a continuous process, to aluminium strip, and consists of units in which the strip is washed, anodised, coated with lacquer, and stoved. The anodising process ensures the maximum adhesion of the lacquer and enables the material to be subjected to forming without breakdown of coating. Known as "Anolac" the product will use Noral M57S in all tempers and Noral 2S and 3S alloys in all tempers except fully annealed. The line, of which we reproduce a general view looking from the coiler towards the drying tower, was constructed under the supervision of Alcan Industries' general engineering department and will be used initially for coating material up to 26in wide and from 0·008in to 0·018in thick, depending upon the alloy and temper of the strip.

The diagrammatic flow chart indicates the various processes in the production of "Anolac": these commence with the



**Prototype cannery line with the blanking and cup forming press on the right**



Flow diagram of anodising and lacquering line

placing of a coil of strip in the uncoiler from where it is passed through the various units in the line and finally to the coiler as finished strip. The process is continuous, the design permitting new coils to be added without stopping operations, for when the end of the coil is reached the hold clamp keeps the tail of the strip stationary while a new coil is mounted and the old and new strips are joined by a spot welder. On release from the clamp the strip moves into the infeed accumulator which consists of a system of rollers normally accommodating about 160ft of material between the welder and the first drive unit. This length of strip allows the line to continue to move, and should the strip in the accumulator be exhausted before the welding operation is completed then an automatic switch stops the drive and cuts off the current in the anodising tank. The drive unit is the first of four which maintain the speed and tension of the strip and which are connected, through eddy-current couplings, to constant speed motors, and are electronically interconnected. The electronic circuit has a time control to prevent acceleration or deceleration of the strip beyond fixed limits, and the tension of the section between drives can be maintained at any selected amount.

Degreasing and cleaning are carried out in the alkali rinse unit where the strip passes through an alkali wash, cold and hot water rinses and is then air dried. Electrical contact for the strip while in the anodising tank is provided in the contact roll assembly which incorporates a scraper blade to keep the roll clean and ensure efficient electrical contact. Also incorporated is a drive having a constant torque to prevent any relative motion between roller and strip with subsequent sparking. Rubber lined mild steel forms the anodising tank which has lip pattern fume extraction equipment. The electrolyte is 15 per cent sulphuric acid and the tank has a rating of 4000A at 12V to 24V, with a designed film thickness of 0·3 microns at a line speed of 100ft per minute. A squeegee roll removes the surplus acid and also provided are preheating equipment and cooling coils to control the electrolyte temperature during anodising. After a water rinse to remove all traces of electrolyte the strip enters the drying tower where it is dried with hot air from a 100kW thermostatically controlled heater and then cooled off with cold air. After passing through the master drive unit which controls the strip throughout, the strip moves on to the coater in which lacquer is applied to each side of the strip by two sets of rolls. Each set is of three roll reversible pattern, the rolls being driven by a constant speed electric motor through a variable speed hydraulic gearbox. Gaps between the rolls, which are adjustable relative to each other, meter the thickness of the coating, the control of which is effected by weighing a sample of coated strip of fixed size. If required the metal can be coated on one side or with different lacquers on both sides.

Drying of the coated strip is carried out in a gas-fired stoving oven having five zones to ensure controlled heat distribution. The strip is unsupported while passing through the oven which is 70ft long, can operate at temperatures up to 700 deg. Fah., and is fitted with flame failure devices. In the cooling unit the strip is cooled by cold air and is then passed over water-cooled rolls to the second drive unit which is similar to the first in construction and duty. Next in sequence is the outfeed accumulator which performs a similar function to the infeed accumulator but in reverse, in that it normally runs empty but can store up to 100ft of strip while a completed coil is being removed. The last of the subsidiary drive units, the third, incorporates a tension control for the coiler, before which is a hold clamp which holds the metal while it is cut by guillotine. Upon the removal of the completed coil the clamp is released and the strip, held in the outfeed accumulator, begins to run to start a new coil.

The main equipment suppliers were: Electrochemical Engineering Company Ltd. (alkali rinse, contact roll, anodising tank, water rinse and drying tower); Loewy Engineering Company Ltd. (coiler); Sciaky Electric Welding Machines Ltd. (spot welder); and Stordy Engineering Ltd. (accumulators, drive units, coater, stoving oven, cooling unit).

View of continuous anodising and lacquering plant looking from coiler towards drying tower

## Technical Reports

*Intrinsically Safe Electrical Apparatus: Relation of Igniting Current to Circuit Inductance for a Mixture with Air of the Vapour of* (1) *Methyl Acetate and* (2) *Acetaldehyde.* (Ref. D/T119). By D. H. Jones, Grad. I.E.E., and N. L. Heathcote, B.Sc. The Electrical Research Association, Cleeve Road, Leatherhead, Surrey. Price 6s., postage 6d.—The investigation described in this report is another in the series which is being carried out at the Safety in Mines Research Establishment to determine the relative ease of ignition by break sparks of the various inflammable gases and vapours used in industry, in order to group them and to choose the representative gases and vapours for test purposes. Methyl acetate is a member of the group of saturated esters: it is placed in Group IId of B.S. 229. Acetaldehyde is used in the manufacture of plastics and of acetic acid: it is not listed in B.S. 229.

*The Performance of Compaction Plant in the Compaction of Two Types of Granular Base Material.* By W. A. Lewis and A. W. Parsons. H.M. Stationery Office. Price 2s. 3d.—In recent years, premixed water-bound macadam—or wet-mix, as it is more generally called—has been widely used for road bases. It consists of graded crushed aggregate mixed with a small amount of water. The Road Research Laboratory has investigated the performance of a wide range of compaction plant in the compaction of a wet-mix limestone and a wet-mix slag in common use, and the results are published in this report. Information on the performance of plant, the moisture range within which the materials should be used, and the state of compaction that can be obtained, is given.

*Guss im Bergbau.* Second revised edition. Düsseldorf: Zentrale Für Gussverwendung, Düsseldorf, Sohnstrasse 70. Free on demand.—The present booklet, which was first published on the occasion of the German Mining Exhibition in 1958, has now been reissued by the ZGV in an expanded and revised version. The principal sections deal with the applications of castings in mine construction, in mining machinery and installations, and in cokeries. A final chapter surveys the grades of cast iron and steel now available for various purposes.

# Computer Experiment in Air Traffic Control

*Preliminary details were given last year at the I.E.E. symposium on air traffic control of a project for investigating the uses of a computer in this application. An account of these proposals appeared in our issue of April 15, 1960, page 638. The Ferranti " Apollo " computer selected for the purpose is now in experimental service at the Oceanic Area Control Centre, Redbrae, Ayrshire. We describe below the manner in which it is being used and some concurrent developments in the communications which provide the data essential for air traffic control however it is exercised.*

IN deciding to experiment with the use of a computer for carrying out certain tasks now performed by air traffic controllers, the " Apollo " Computer Unit of the Ministry of Aviation had the general aims of increasing efficiency and reducing the controllers' workload. Lengthy paper studies were made before the computer was installed at the Oceanic Area Control Centre, Redbrae, and now that this facility is available, the project is still in an evolutionary stage. Its full potential will be realised by experiment, guided by the principle that what is being sought is automatic assistance rather than full automation of air traffic control. In this way the unit hopes to discover what can be expected of a data processing system now and in the future, and where the human element fits into such a system.

The basic tools of air traffic control are the flight plan of each aircraft passing through the controlled zone, showing its heights, estimated times, and latitudes as it crosses each 10 deg. meridian of longitude ; and the reports from the aircraft itself during flight which show whether the plan is being implemented or deviations have been made from it.

Redbrae deals with aircraft in the North Atlantic area as far as 40 deg. west. Information reaches it over numerous teleprinter channels from airports and from other air traffic control centres, and is, therefore, already encoded in a form suitable for direct input to a computer. Position reports from aircraft originate as radio telephony and are taken down direct on a teleprinter keyboard by the operator at the ground receiving station in a shortened form. This transmission of the information to the control centre takes place simultaneously with reception, but messages are repeated back to the aircraft for confirmation and corrections are sent as necessary. Information from fixed stations on both sides of the Atlantic, as well as from Iceland and Greenland, was carried originally by a large number of radio teleprinter channels, often duplicated in order to guarantee communication. Those communications are now being transferred to the various transatlantic telephone cables as they become available. When the first of these was opened, a part-time speech channel was set up between Redbrae and Gander, and extended in 1959 to twenty-four hours' service, although still using the cable only for part of the time and filling in with a radio speech circuit. When the ICECAN and SCOTICE cables are in service there will be a voice channel and four teleprinter channels between Redbrae, Reykjavik, Prince Christiansen and Gander, with arrangements for restoration of service in five minutes in the event of breakdown by taking up spare channels in the CANTAT cable. For the first time a twenty-four hour telegraph connection across the Atlantic will then be ensured for air traffic control.

Communication with aircraft continues to be by telephony on h.f., except close to the air traffic control centres, where v.h.f. is used. In addition there is an experimental ground-to-air teleprinter weather report service on 120 kc/s from a station near Stranraer. Experience has led to the conclusion that in conjunction with a similar station at Gander this could provide a completely reliable means of transmitting information from the ground to aircraft in the North Atlantic area. All the VC-10 aircraft of B.O.A.C. will be equipped to receive the existing service from Stranraer.

The low frequencies are less suitable for radio telephony, and experiments have been made in the use of v.h.f. for communication beyond line-of-sight ranges. Using a 50W transmitter with directional aerials in the Isle of Lewis, contact has been established with jet aircraft at ranges of 300 or 400 miles. This facility has received international support and a 1kW operational station is to be set up in 1962–63 on the Isle of Tiree.

There is still far to go before communications operate directly between computers on the ground and in the air, but already the computer can assist the air traffic controller in dealing with and interpreting the data flowing to him through the various channels. The Ferranti " Apollo " computer at Redbrae (Fig. 1) with its associated input and output equipments is the first computer installation in the United Kingdom to be devoted entirely to the problems of air traffic control. At present it works in parallel with the normal control organisation, being fed with sample actual flight plans and position reports from a data input room where four " Creed 75 " teleprinters with keyboards are installed. Data passes straight to the buffer store of the computer and is simultaneously printed out for checking. When the operator is satisfied that it is correct, he presses a button which causes the information to be transferred to the main store.

Four controllers, each allotted a particular section of the area, are seated at " Creed 75 " printers on which information from the computer is presented to them. Each has a keyboard by means of which he can interrogate the computer for information. He may, for example, request information on any aircraft which have not reported position. The computer recognises the time at which the request is made and prints out the identities of any aircraft which have not reported within fifteen minutes of the time when such a report was due, giving the longitude from which the report should have been received and the time by which it is overdue.

Flight plans are tested for conflict as soon as they are fed into the store. The computer first checks the programmed heights with those already filed by a process of subtraction, conflict being revealed by a zero answer. When a conflict in this or other respects is detected, notification is routed to the output printer of the controller concerned. Similar tests are made for conflicts due to the developing traffic situation, as revealed by position reports and estimated positions. If the controller concerned is temporarily unable to accept these notifications, they are put into a queuing store and printed out as soon as he is free.

When position reports are fed into the computer, the machine checks with the flight plan and prints out a notification if there was an error of over half a degree from what was intended, or if the time is ten minutes before or after the forecast. A cancellation message is originated when an aircraft leaves the system. These facilities are expected to improve the efficiency of control by relieving controllers of the need to look out for conflicts, and allowing them to concentrate on their resolution. Although, at present, flight progress strips embodying the position information arriving *via* the computer are prepared manually, it is intended very soon to modify the programme so that the strips are printed out.

At present the computer is arranged to handle up to 100 aircraft, for each of which twenty data registers are provided in the store. The time taken to make a height conflict check, for example, is twelve

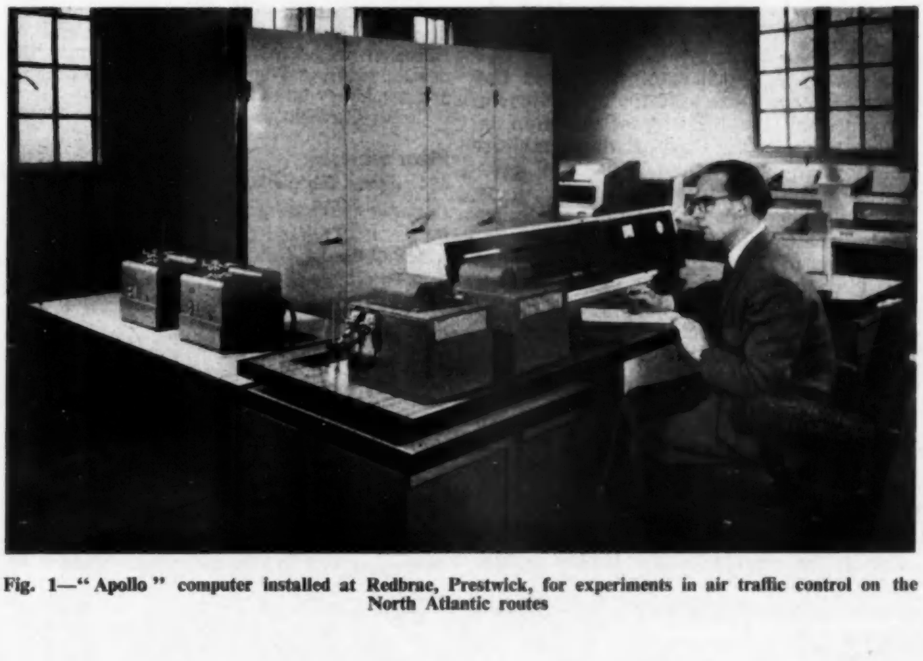


**Fig. 1—" Apollo " computer installed at Redbrae, Prestwick, for experiments in air traffic control on the North Atlantic routes**

$\mu$ seconds, so that in examining this information for the full 100 aircraft only 1·2 milliseconds would be occupied. At present the peak density in the control area is fifty or sixty aircraft within the system at any one time.

Some other typical examples of computing speed in the A.T.C. application are :

Interpret and store a flight plan for a typical westbound aircraft, thirty-three milliseconds.

Test that the flight will not infringe separation standards with the other 100 aircraft in the system, 120 milliseconds.

Prepare data for four flight progress strips for the typical westbound flight, five milliseconds.

The time to input the flight plan from a keyboard is dependent on the speed of the local operator (about forty seconds), and the time to output the flight progress strips is determined by teleprinter speed (about ninety seconds).

The " Apollo " computer was constructed at the computer research establishment of Ferranti Ltd., at Bracknell, Berkshire. It consists basically of three cabinets, as seen in Fig. 1, each 6ft high, 22in wide and 19in deep. A fourth cabinet seen in the illustration contains electronic equipment developed by the Ministry of Aviation in conjunction with the Royal Radar Establishment for cathode ray tube displays. Experiments are to be conducted on the usefulness of displaying alpha-numerical and other information to the controllers by this means. The nature of the picture displayed is under the full control of a stored programme which feeds data, as often as required, to the display electronics *via* a twenty-four-bit register. Eighteen bits in this word are used to define the *x* and *y* co-ordinates of a dot on the tube face which is to be brightened up. The definition will, therefore, be equivalent to 512 lines vertically and horizontally. The remaining six bits in the register are used for control purposes such as write, erase, select one of four displays, &c.

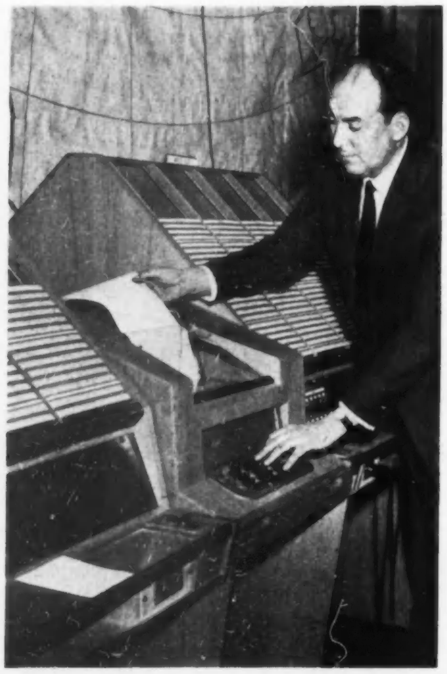


Fig. 2—One of the controller's positions, showing computer interrogation keyboard, output printer and flight progress strips

The display electronic circuitry, which converts the contents of the display register into a picture on the tube face, has been developed by the Royal Radar Establishment. When displaying alpha-numerical characters each character is specified by ten dots within an $8 \times 8$ grid, giving a maximum capacity on the tube face of 4096 characters ($64 \times 64$). A reference point in each small grid (the top left hand corner) is used to determine the position of the character on the display.

Each cabinet of the computer is equipped with cooling fans to provide a small degree of forced ventilation necessitated by the close packing of the circuit boards and the compactness of the whole assembly. No air-conditioning or temperature control arrangements are necessary in the room where the computer is installed.

Fig. 2 shows one of the output printers at a controller's position. Some 400 circuit packages are used in this all-transistor, high-speed parallel machine, but about 80 per cent are of six basic types. Each printed circuit package measures about 11in by 6in. They are held in nylon runners, thirty to a shelf, and there are eight shelves in each cubicle. Two cubicles are required for logical packages and the third contains the two ferrite stores, space for a further data store, and the computer power pack. The c.r.t. display electronics are not packaged.

The power supply consists of a 5kVA stabilised motor alternator which works from the three-phase 50 c/s mains and provides a three-phase 400 c/s output. This leads to simplification and lightening of the computer power pack, which consists of three-phase rectifier circuits and simple choke-input ripple filters, without further stabilisation.

The floor area occupied by the complete computer and control desk is about 10ft square. Total dissipation in the computer (excluding the display electronics which uses vacuum tubes and has its own power supply) is under a kilowatt. Apart from the motor alternator, which must be mounted on a concrete base, there are no floor loading problems, and specially strengthened floors are not required. The equipment is designed to break down, if necessary, into units small enough to pass through normal doors.

Operational features of the " Apollo " computer are its high speed, mainly due to the parallel arithmetic unit and immediate access core stores, and the 500 kc/s digit rate which enables fairly simple circuits to be used. A programme can be interrupted at any time and a wide variety of special sub-routines inserted into the programme automatically. This interrupt facility, which is carried out on a priority basis, enables the computer to deal with data-processing functions which originate with little or no advance notice, a particularly important factor in real time applications such as air traffic control. A time-sharing facility is also incorporated which ensures that the computer is always fully engaged even while peripheral transfers are taking place. Although operational programmes have priority, the computer can also be used for carrying out routine calculations and developing programmes.

In twelve weeks' use the computer has operated for 600 hours and has had about ten hours for downtime. Seven of those hours were in the first five days of working, so that only about three hours' downtime occurred in the next eleven weeks.

# Books just published

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*Translated by A. Hertl and E. Lohmann.*

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This is a translation of a book which was published in Germany in 1959 and deals in the main with German developments. The author details the basic principles underlying the determination of rating and design features of extrusion presses of all types. He traces the developments and improvements in techniques and machinery up to the present day.

[Reply Card No. 1428]

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*including Chapters on Photogrammetry*

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This book is intended for students reading first year university courses in surveying and for those taking the examinations of the professional institutions. The ordinary procedures of plane surveying are covered as well as the recent electronic methods of distance measurement and the latest developments in photogrammetry. Modern instrumentation is also discussed. There are specific references at the end of each chapter as well as a bibliography. There is an index and an appendix of examples.

[Reply Card No. 1431]

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797 *pages. Illustrations. Diagrams.*

*Publisher : Prentice-Hall International Inc.*

*by LAWRENCE E. DOYLE, JOE L. MORRIS, JAMES L. LEACH and GEORGE F. SCHRADER.*

*Price* 70*s.*

Three of the authors of this book are in the Department of Mechanical Engineering at the University of Illinois and the book is based on the manufacturing processes course at that University. The approach throughout is to explain the principles upon which manufacturing processes are based and to describe practices to illustrate the principles. The chapters range over subjects as diverse as fundamental metallurgy, plastics, welding, machine tools and automation. There are brief lists of references, questions and problems attached to each chapter.

[Reply Card No. 1433]

**Handbook of Transistor Circuit Design**

565 *pages. Diagrams.*

*Publisher : Prentice-Hall International Inc.*

*by KEATS A. PULLEN.*

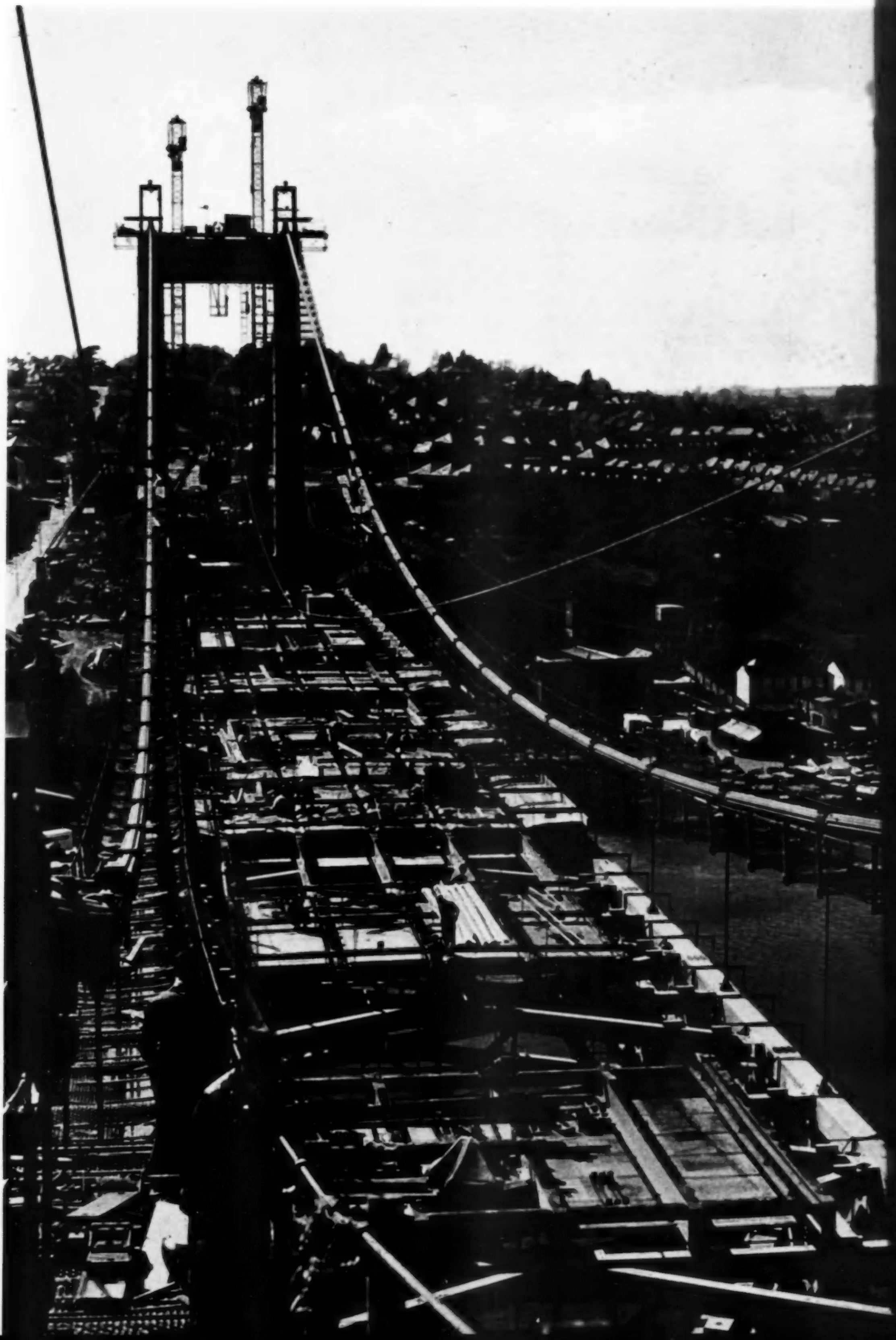
*Price* 50*s.*

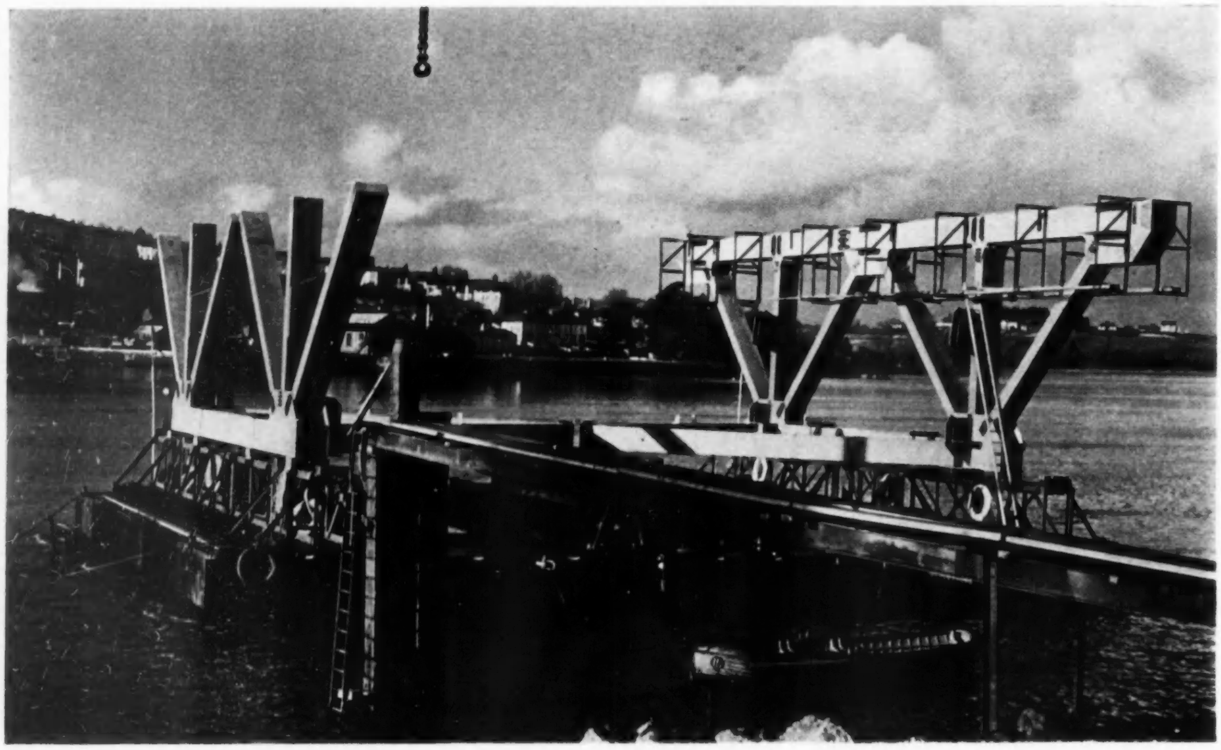
This book is intended as a guide to a systematised approach to the design of circuits for transistors and other active devices. It gives design procedures which should significantly improve the potential reliability of transistor circuits, the methods used being subject to considerable mathematical and scientific scrutiny prior to adoption. The appendices contain a table of symbols and definitions, and a derivation of the small signal distortion equation, brief reviews of topological analysis and orthogonal analysis. There is an extensive bibliography.

[Reply Card No. 1434]

# Constructional Views of the Tamar Suspension Bridge

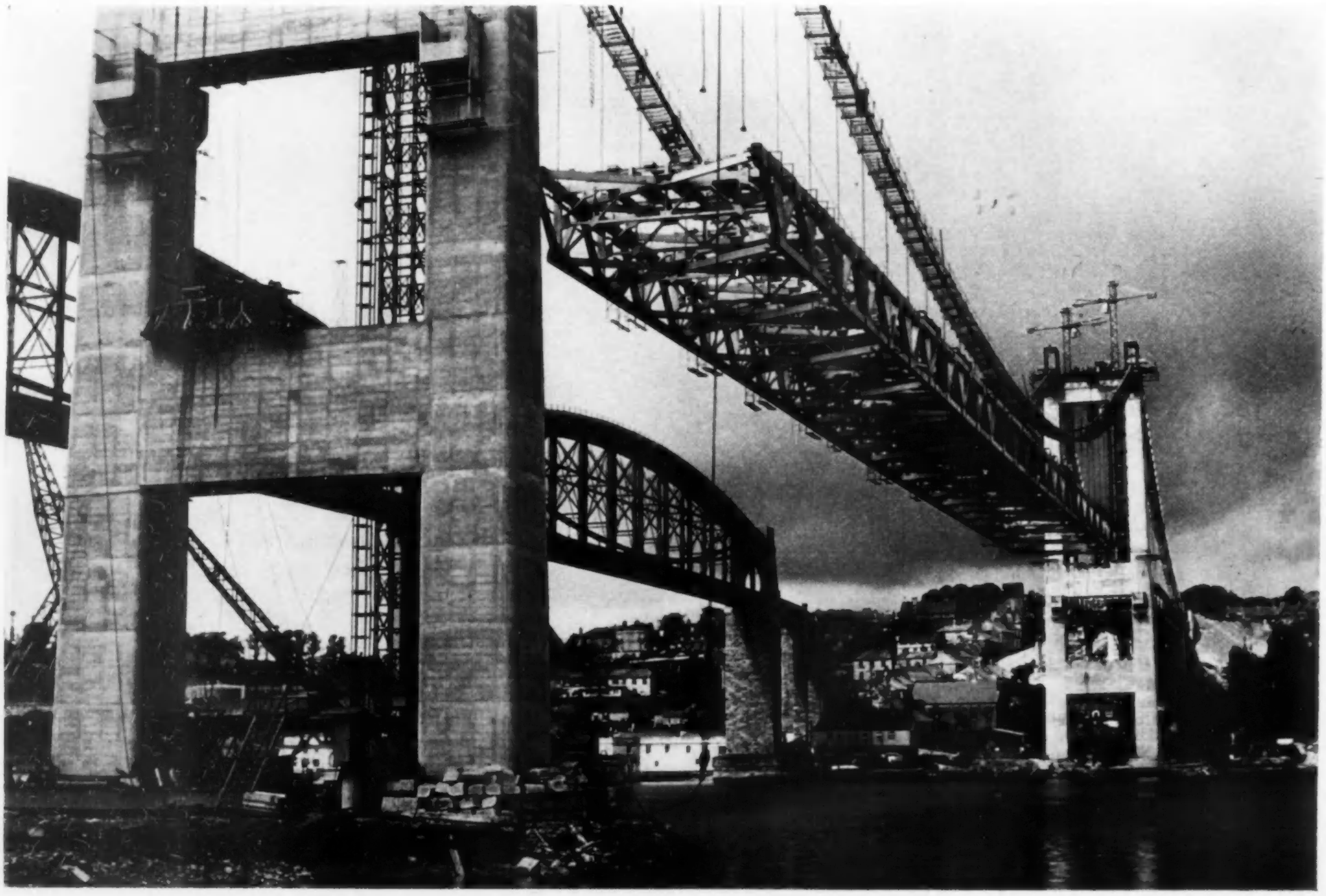
The Tamar suspension bridge was partially opened to traffic last October, before its completion, and it is to be inaugurated next Spring. The bridge links Devon and Cornwall ; it has a main span of 1100ft, and two side spans, each of 374ft, and will carry three lanes of traffic and two footpaths. The illustrations in colour here depict various stages during the construction of the bridge.





A SECTION of the stiffening girder is shown being erected on a pontoon, ABOVE, and such a section is seen being lifted to its final position in the structure, ABOVE RIGHT. The stiffening girder is a substantial trussed construction, largely in welded high-tensile steel of "box" section, with site joints made by "grip" bolts. The deck construction is well shown BELOW RIGHT; the concrete slab is joined to the steel stringers by shear connectors forming a composite construction, but the stringers can slide on the transverse beams of the stiffening girder assembly. A good general idea of construction of the suspended structure is given by the illustration on the preceding page. Brunel's Royal Albert Bridge is also seen in the view BELOW.

The bridge has been constructed for the Tamar Road Bridge Joint Committee, acting for Plymouth City Council and Cornwall C.C. and is being operated as a toll bridge. The consulting engineers responsible for the bridge are Messrs. Mott, Hay and Anderson, and the main contractor is the Cleveland Bridge and Engineering Company Ltd.



The main towers of the bridge are built of reinforced concrete, to a somewhat slender "no tension" design. Another interesting point in design lies in the use of locked coil ropes for the suspension cables. The ropes were brought to the site cut to length (2200ft), and coiled on drums. Previously, they had been repeatedly loaded and unloaded at the makers' stressing bed, until the apparent modulus of elasticity of each rope could be guaranteed within the close limits of ±2 per cent specified by the consultants. The suspenders for the deck were also locked coil ropes to this specification. By virtue of this procedure, much quicker erection than would have been possible by "cable spinning" with parallel-wire construction was achieved. Further, the accuracy of erection was such that the suspenders were specified to their exact lengths, and no adjusting devices were needed in their permanent attachments (in fact adjustment was needed during construction, as the bridge took up deformed positions at various stages of hanging the suspended structure). British Ropes Ltd. supplied the locked coil ropes.

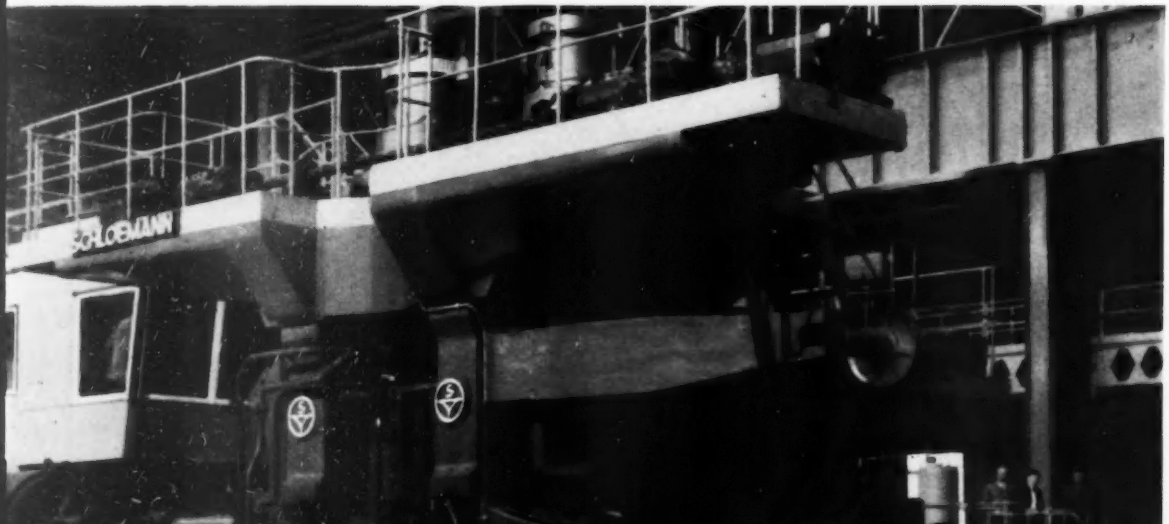
The cable anchorages are in 50ft tunnels in the rock on each river bank. The main towers rest on caissons. The deck is carried above the girder structure (the deck has no central openings) and although there is no damping, there is rocker-arm control of deflection of the suspended structure at the towers. Temperature movements of the suspended structure are taken up at a single joint at the Saltash tower.

SCHLOEMANN
SCHLOEMANN

# Universal Beam Mill at Scunthorpe

ROLLED steel beams with parallel or near-parallel flanges have important advantages over orthodox joists. Their favourable ratio of deadweight to modulus of section, in particular, makes them attractive over a wide range of structural applications, and demand for universal beams and columns is increasing. The principle of the four-roll or universal mill used in the production of such beams was evolved many years ago, but more recently there have been numerous developments, and the universal mill recently commissioned at the Scunthorpe, Lincolnshire, works of the Appleby-Frodingham Steel Company (a branch of the United Steel Companies Ltd.) exemplifies the latest practice.

Three roll stands are used, one for roughing BELOW, one for finishing ABOVE, and the third for edging. This latter is adjacent to and forms a group with the roughing stand, by which it is hidden in the illustration. The main roughing and finishing stands, as will be seen from the illustrations, are mechanically identical, though the work they do is different. This simplifies both operation and maintenance.



# Letters to the Editor

### HYDROLOGIC NETWORKS AND METHODS

Sir,—Last week my attention was directed by the Secretariat of the World Meteorological Organization to a review published in the July 21, 1961, issue of The Engineer of "Hydrologic Networks and Methods." Inasmuch as I was one of the participants in this seminar reported, I should like to have the opportunity to respond to your review.

Apparently one of the major quarrels of your unnamed reviewer is with the application of probability techniques to engineering problems. For example, the reviewer states "The law of probability may be of limited and provisional use for calculating mean values but cannot serve as a basis for design unless regular and frequent observations have been recorded for many years." This pessimistic view is surely not supported by any modern methods of analysis. Probability analysis is applied in day-to-day hydrological forecasts throughout the world even where only relatively short records have been collected. They are applied regularly in estimates of floods (see for example the long series of reports by the U.S. Geological Survey on flood frequencies). Moreover, the quoted statement denies the valuable work now being carried out in the application of stochastic models for the design of river works (see for example P. Moran, "A probability theory of dams and storage systems," *Australian Jour. Applied Sci.*, 1954, pages 116 to 124). Or the derivation of important design rules that are independent of lengths of record—the finding by Prof. H. A. Thomas, Jr., of Harvard University "that the optimal level of reservoir draft is uniquely determined by three parameters of the benefit function," is an example of the fundamental hydro-economic relations evolving out of probability analysis. The Engineer should become familiar with the research in this field by the Water Resources Center at Harvard. If any criticism of the Bangkok Seminar is merited on this subject, it should be that the methods described are too limited. More can be done and is being done in the application of probability theory in the solution of water-resources problems.

The unnamed reviewer also disputes the principles of efficiency in the design of hydrologic networks. He argues instead for a plan of determining the minimum data required to plan a viable water utilisation scheme and then estimate the cost of collecting these data overlooking the several pages (pages 17 to 20, inclusive) which deal specifically with the minimum desirable network in several classes of data. One may properly disagree with the criteria offered, but it is hardly fair to imply the neglect of the minimum.

But even establishing a minimum does not relieve an engineer of designing that network to "provide the maximum information for a given investment of *time* and money" (to quote the exact language of the report). The experience in all countries in which this author has had any experience supports the observations of Dr. Kalinin in the Soviet Union (on page 42) that the dense networks of data sufficient to meet all practical requirements by using the results by direct observation are prohibitively expensive in terms of time and cost.

If there is any experience that is repeatedly confirmed, it is that any scheme of water-resource development invariably encounters a deficiency in hydrologic data—even where networks are dense. It is then that the engineer must turn either to some method of extrapolation or delay his project for a period of time sufficient to collect the needed data. The latter is hardly an acceptable alternative, and besides goals would change in the meantime and new deficiencies would occur. There is no alternative to some form of extending or extrapolating from available data—and the better the data, the better are one's tools, and the better are the results. Hence, some kind of network design is needed to assure efficiency. This is a proper engineering objective—the Bangkok Seminar presented one set of principles—surely it would be proper to acknowledge that these can be improved. Consequently this task is to be taken up by a Work Group of the World Meteorological Organisation.

The reviewer naïvely cites two examples to demonstrate the variability in behaviour of rivers. More important it is to understand the nature of and the reasons for this variabilty; but because one's understanding is never complete, it is stated repeatedly (pages 24, 27, 28) that field checks on any estimate are essential.

The reviewer states that one must distrust the results of the seminar because there is no comparison of a forecast with a subsequent flood. This statement chooses to overlook the fact that where forecasting methods are explained they are in essence those in daily practice in the U.S.A. and the Soviet Union. The references cited record the results of this experience. I might also cite Committee Print 25 of the U.S. Senate Select Committee on National Water Resources which summarises experience in this country.

Further details :

(1) With regard to the reviewer's observation "Difficulties in trying to use the same reservoir for both flood prevention and water supply support the opinion held by many U.S.A. engineers that such a reservoir will be inefficient in both its objectives." This is hardly correct to-day. For example, the Corps of Engineers states (Committee Print 15, Senate Select Committee on National Water Resources, 1961) "Perhaps the most important contribution made to the needs of water supply and pollution abatement by reservoirs provided under the flood-control programme has been the augmentation of low flows by releases of water from conservation storage pools." It is a rare flood reservoir to-day that is not managed so as to provide for augmentation of water supply. Committee Print 25 has examples to show how hydrologic forecasts make this possible.

(2) The reviewer misquotes me by attributing to me the remark "that errors of up to 50 per cent are not unusual" and then proceeds to imply that I meant that greater errors do not occur and to quarrel with such terms as "normal maximum" and "greatest known maximum" which are not in my report. My actual words in relation to the unit hydrograph were "Errors of 50 per cent, especially for the smaller streams, are not unusual." The context of the paragraph from which this sentence was misquoted was to provide an estimate of the accuracy of unit hydrograph peaks of *ungauged* streams, not for "forecasting" as stated by your reviewer.

(3) A re-reading of Paper 15 by Mr. Ahuja does not support the reviewer's deductions.

(4) One may categorically refute the reviewer's statement that Mr. Takenouchi's paper deals with flood warnings or forecasting. The variations in Mr. Takenouchi's factor *f*, which so seems to alarm the reviewer, have nothing whatever to do with flood warnings ; Mr. Takenouchi's problem, like that of all flood-control engineers, is to estimate flood discharges for the design of flood-control works.

To paraphrase the reviewer's closing sentence—the title of this review should surely be "Selected quotes can prove anything."

Walter B. Langbein,
Civil Engineer.
United States Department of the Interior,
Geological Survey,
Washington D.C.,
December 5, 1961.

## Books of Reference

*Dictionary of Agricultural Engineering : Handbook for Engineers, Farmers and Students.* By H. J. Hine, B.Sc.(Oxon.). Heffer and Sons Ltd., Cambridge. Price 15s.—The headings in this dictionary are arranged in alphabetical sequence, and approximate translations of these are given for French and German. In many cases there is a brief note on the evolution of the machinery referred to, together with a derivation of the English name. Related subjects such as atmospheric and soil physics are included, as are lists of abbreviations in common usage, and conversion tables. There are cross references in many of the articles, and users of this dictionary are expected to have some knowledge of agricultural machines and processes.

[Reply Card No. 1239]

*Skrocony Slownik Mechaniczny Polsko-Angielski. A Concise Polish–English Dictionary of Mechanical Engineering*. Warsaw : Panstwowe Wydawni Ctwa Techniczne, 10, Ul. Mazowiecka 2/4, Warsaw. Price zl 46.—The present *Concise Polish–English Dictionary of Mechanical Engineering* lists some 15,000 technical terms taken from the *English–Polish Dictionary of Mechanical Engineering* previously published by PWT. All one-word terms in the latter dictionary have been included, but in order to achieve conciseness, some of the complex terms were omitted ; in such cases the reader is referred to the parent dictionary.

[Reply Card No. 1248]

*British Shipbuilding Compendium. Eleventh edition*, 1961. Gibbon and Tookey, 6, Bromley Grove, Shortlands, Kent. Price 25s.—This book lists firms engaged on building and repairing ships in Great Britain, as well as the main sub-contracting firms who supply fittings and equipment for use in ships. Sections are included on propulsive machinery, general equipment and shipyard equipment. The sections are listed alphabetically in the contents list, and indices to section headings and all firms mentioned in the volume complete the work.

[Reply Card No. 1495]

# 500MW Turbo-Generators for Eggborough

FOUR 500MW turbo-generators are to be built by Associated Electrical Industries Ltd. for the C.E.G.B. power station at Eggborough, on the River Aire, about 4 miles to the east of Knottingley, Yorkshire. This A.E.I. order for Eggborough is worth nearly £14,000,000 and includes four 3000 r.p.m. single-axis turbine-generators, condensing plant and turbine-driven boiler feed pumps. The first unit is due to be commissioned in 1966 and all four units are scheduled to be in operation by 1968.

The 500MW single-axis unit is a later development of the 550MW double axis unit already being manufactured by A.E.I. which is the highest rating of units so far ordered in this country. The 500MW design concentrates the maximum capacity up to the present in a single-axis unit and will result in the most economical generation project in terms of capital and operation costs and thermal efficiency.

Each 500MW unit consists of a five-cylinder, 3000 r.p.m. reheat turbine for steam inlet conditions of 2300 lb per square inch gauge 1050 deg. Fah., the steam being reheated after the first high-pressure cylinder to a temperature of 1050 deg. Fah. The turbine is directly coupled to a 500MW two-pole generator using hydrogen and water as cooling media. Steam is tapped off the turbine after the high-pressure cylinder to supply a turbine of about 15,000 b.h.p. output for driving the main boiler feed pump.

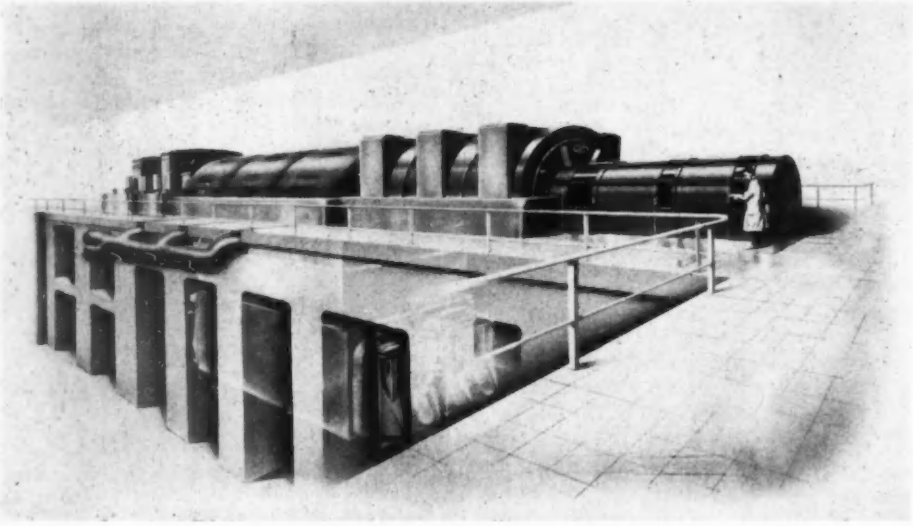
*Turbine.*—The main turbine contains a high-pressure cylinder, an intermediate-pressure cylinder and three low-pressure cylinders. The rotor of each cylinder is supported by two bearings and all rotors are solidly coupled together. The assembly of cylinders is anchored to the foundations at the low-pressure end, the rotor assembly being fixed relative to the cylinders by a thrust block at the high-pressure end. Differential expansion between rotors and cylinders will be accommodated and A.E.I. " Turbovisory " equipment will closely supervise differential expansion, rotor eccentricity and vibration.

Steam exhausted from the high-pressure cylinder passes to the reheater and re-enters the turbine in the centre of the double-flow intermediate-pressure cylinder. Steam exhausted from each end of this cylinder is distributed by pipes to the three low-pressure cylinders, each of which is arranged for double flow. The six exhausts from the turbine are connected into an exhaust piece to which the condenser is bolted. The condenser is of special design and is arranged axially under the turbine as can be seen from the artist's impression reproduced here. The design accommodates the total cooling surface (300,000 square feet) in a single shell. A.E.I. was the first manufacturer to apply this design to large generating units. The designed condenser vacuum is 28·7 Hg at full load.

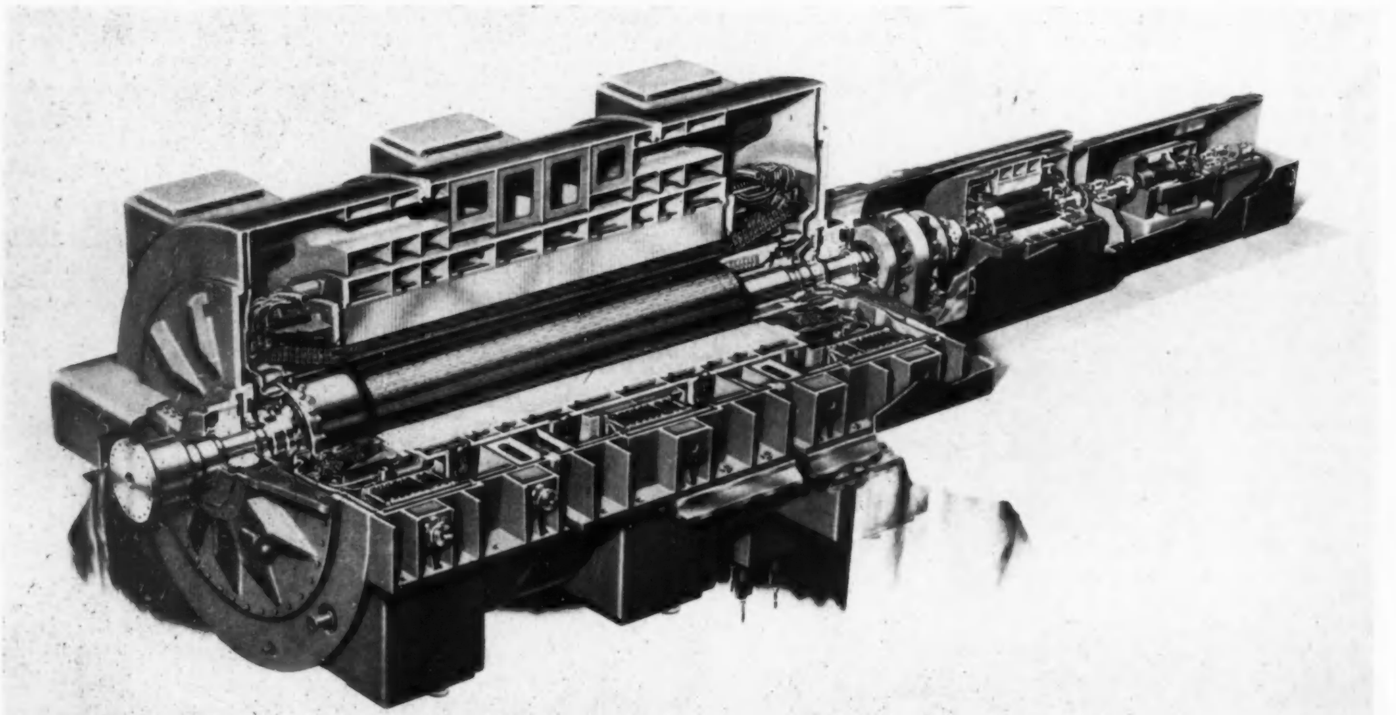
*Boiler Feed Pump Turbine.*—A turbine of about 15,000 b.h.p. capacity operates in conjunction with the main turbine for driving the main boiler feed pump. The steam supply is taken from the main turbine after the high-pressure cylinder. This turbine is arranged as a bled-steam, back-pressure machine, the steam tapped from the various stages and the exhaust steam being used for feedwater preheating.

*Generator.*—The generator is designed for three-phase, 50 c/s, 22kV, 0·85 power factor and 0·4 short-circuit ratio. Cooling is by hydrogen at 45 lb per square inch pressure and, in addition, the stator windings are direct-water-cooled, utilising a technique first introduced into service by A.E.I. in 1956 in a 30MW machine at Bold power station—a technique which results in reduced weight per kilowatt of output.

For the Eggborough site the transportation limit is 240 tons. To reduce the transport weight to the minimum, the stator core and windings are built in a light cage framework (illustrated below) which is subsequently inserted in the gas-tight outer casing on site. The stator conductors are in the form of hollow copper tubes, through which cooling water is circulated



**Artist's impression of a 500MW, A.E.I. turbo-generator**



**Perspective cut-away view of typical 500MW, A.E.I. turbo-generator**

between manifolds at both ends of the windings. The water is passed in closed circuit through heat exchangers where the heat generated in the stator windings is extracted for return to the feedwater system and thereby recovered in the turbine cycle.

The generator rotor and the stator core are cooled by hydrogen, at a pressure of 45 lb per square inch. The rotor is a solid forging with windings arranged for cooling in direct contact with the copper. To carry the hydrogen into direct contact with the rotor copper, a series of axial and radial passages are constructed by grooving the copper axially and punching slots radically through each turn. Hydrogen is fed to the radial slots through openings in the insulation arranged at intervals along the length of the coil and, after passing axially through the grooves, is discharged to the air gap from adjacent radial slots. This arrangement ensures uniform cooling throughout the length of the rotor. To cool the stator core hydrogen is circulated by fans mounted on the shaft, through radial ducts provided in the core. The hydrogen circulated through the rotor and stator core is cooled by heat exchangers built into the generator casing. By using condensate as the cooling medium the stator heat losses are recovered in the turbine cycle.

The excitation source is a direct-coupled, four-pole a.c. generator, the output of which is rectified by a bank of silicon rectifiers directly connected to the main generator sliprings. An automatic voltage regulator varies the a.c. generator excitation to suit the load requirements of the generating unit. The use of this system avoids the gearbox drive and large diameter heavy-current commutators which would be necessary with d.c. exciters.

*Condenser*.—The condensers, similar to those being supplied by A.E.I. to C.E.G.B. Ferrybridge Power Station, are axial units designed to overcome the problems of turbine foundation supports associated with transversely arranged condensers. Special provision is made for completely balancing the hydraulic thrust of the very large cooling water pipes and the double tubeplates which enclose a pressurised space and for preventing leakage of cooling water into the condensate at the tube fixing.

# Capacitor Installation at Fleet Substation

THE C.E.G.B. substation at Mill Lane, near Fleet, Hampshire, is one of three serving the London area at which it has been decided to install shunt capacitors as a means of helping the lines to handle a greater quantity of active power. This installation was commissioned on November 30, 1961. With a rating of 41·7MVAr it is the largest of the three, and is the first capacitor battery in the country to be connected to the 132kV system. Those at West Weybridge and Elstree will be of 20MVAr rating. The use of capacitors is an experiment in methods of providing control engineers with improved means of regulating power flow, with the advantages of being static and composed of portable units which can be transferred to other substations when needed and re-assembled according to the capacity required, with appropriate series-parallel connections for the voltage at which they are to operate.

At Fleet the capacitor bank is associated with the 275/132kV auto-transformer in the line from West Weybridge, 25 miles away. It is switched in or out by means of off-load isolators, which necessitates opening the 275kV and 132kV circuit-breakers protecting the transformer. The operation is therefore performed at periods of light load when the busbars can be supplied from the second 275/132kV transformer at the substation. Outgoing 132kV feeders from Fleet run to Bracknell, Pyestock, Aldershot, Alton/Reading, Slough, Chichester and Portsmouth.

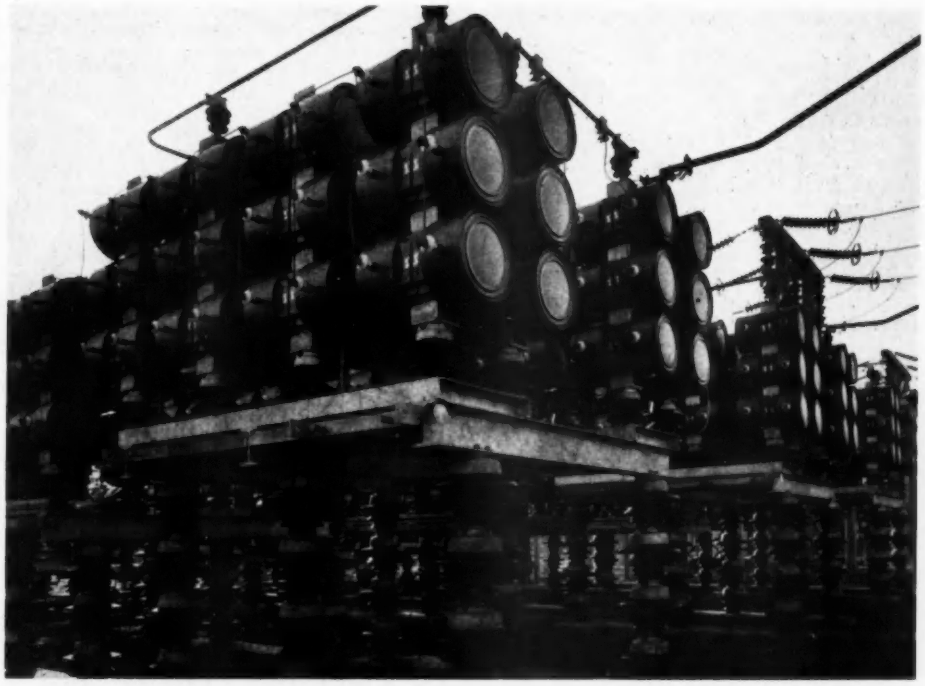
The capacitors and the majority of the equipment for the Fleet installation were manufactured by A.S.E.A. of Sweden and supplied through its representative in this country, Fuller Electric Ltd., who acted as main contractor and undertook erection work. Each capacitor unit is of 81 μF and consists of a drum containing seven rolls forming three individual capacitors. This unit is rated at 1190V, 36kVAr. As seen in the illustration, the capacitors are carried on vertical steel columns which in turn are supported on steel platforms by standard insulators. The platforms are supported from the concrete foundations by one, two, three or four standard insulator units, the number decreasing from the phase end (76kV) to the neutral point. The construction avoids the use of any heavy components and, in fact, lifting gear was only used for unloading vehicles. No cranes or lifting gear were used during the actual erection. Since parts of the installation are close to ground level, it is enclosed by a safety fence. Each phase consists of two parallel paths between the phase connection and the neutral point; each parallel path is made up of capacitor units connected three in parallel, sixty-four in series. The individual capacitor units have a single insulated terminal, the container itself being used as the other terminal. This design enables one set of foils to be in metallic contact with the container, giving good cooling. Highly purified and degasified mineral oil is used as the impregnant and is permanently maintained under a pressure two to three atmospheres gauge by the flexible walls of the hermetically-sealed casing. This pressure serves to prolong the life of the capacitor considerably and also increases the dielectric strength and the "ionisation" or discharge inception voltage. Special welding methods and brazed bushings were used as precautions against leakage.

That foil electrode which is not in contact with the casing is split up into twenty-one sections isolated from each other; each section is connected to the bushing via a fuse. Each phase is separately protected by a compensated balance protection circuit designed to detect fuse failure. The compensating arrangement allows sensitive relay settings to be used, and also makes it unnecessary to "trim" the various portions of the bank to exact values to counteract manufacturing tolerances on individual units. Slight out-of-balance causes an alarm signal and more severe out-of-balance creates a tripping impulse. A thermistor delays the alarm for about a third of a second to prevent operation on transients. A sustained increase in out-of-balance current operates the trip relay through a time-delay relay. In addition a thermal overcurrent relay, compensated for harmonics, is connected to each phase, having a time constant of about forty minutes to match the time constant of the capacitors. Finally, since the capacitor bank is not fed through a separate circuit breaker, the bank is included in the transformer protective zone with which it is associated.

The current transformers for overcurrent protection, for out-of-balance protection compensation and for balanced earth fault protection are connected at the earthy end of the capacitor battery; accordingly they have 11kV insulation. The current transformers for out-of-balance protection are connected at the mid-point on each phase, i.e. at a potential of 38kV above earth. No additional 132kV current transformers have been required.

When switched off, the capacitor bank normally discharges itself through the power transformer with which it is associated. The phase terminals can then be earthed by earthing blades on the capacitor isolator. As an additional safety precaution, for use during maintenance, the capacitor installation is fitted with equipment which permits, first, each of the twelve steel platforms to be earthed simultaneously in one operation, and secondly, each set of sixteen columns carrying capacitors to be earthed in a single operation by a master handle.

The supporting insulators were manufactured by Steatite and Porcelain Products Ltd. Equipment for earthing the capacitors for maintenance was supplied and erected by Power Connectors Ltd. The installation was to the requirements of the Chief Transmission Project Engineer of the C.E.G.B. in conjunction with the consulting engineers, Messrs. Kennedy and Donkin.



**Capacitor banks at Fleet substation, C.E.G.B., showing the three double paths (one per phase) and, in foreground, the grading of insulators from the phase end towards the neutral point**

# SHORTER REPORTS

## Training for Management—Glacier Metal Project

LARGE-SCALE expansion of the Glacier Metal Company's business in post-war years has been accompanied by continuous research into its organisation. This research has produced important results, and the " Glacier Project ", as it is called, has become very well known. Four books dealing with the findings of the project have been published, and the principles evolved have been taught to all the company's senior management, with very satisfactory results. Now, after fourteen years of continuous applied research, Glacier Metal has decided to make the results of its work available outside its own organisation, and has established the Glacier Institute of Management (G.I.M.) Ltd., with premises at 17, King Edward's Road, Ruislip, Middx.

Initially, the Institute will run three-week courses known as management theory courses. These are designed for senior managers and specialists, and for younger men who are making rapid progress towards higher rank. As a guide to the type of man the Institute has in mind, it has suggested those whose level of work justifies a salary above about £1500 per annum at age thirty-two, and £2500 per annum at age forty.

As the Institute develops, further courses will be arranged, for example, a management practice course for managers at the managerial " foreman " level, and more specialised long courses, with intermittent attendance spread out over a greater period of time, for those concerned with personnel work and organisation, as well as with the social sciences. The Institute will also provide series of lectures from time to time on specialised topics. Teaching takes the form of lectures and seminar discussions, reading and study periods, preparation of written material, practical classroom work on various managerial procedures and problems of organisation, and individual tuition and discussions.

The Institute does not provide residential accommodation, but it is easy of access by car and by public transport, being situated only a short distance from two Underground stations—Ruislip and West Ruislip—of London Transport.

## Revised Standards for Hot-Rolled Steel Sections

IN January, 1962, the British Standards Institution will publish a new standard (B.S.4) for hot-rolled steel sections. It will supersede the following current British Standards : B.S.4 : 1932 ; B.S.4A : 1934 ; B.S.4A : Supplement 1, 1959 ; B.S.4 B : 1959 ; and B.S.6 : 1924. In the new B.S.4 : 1962 there will be elements which will contribute to improved practice and greater economy in steel construction. There will be :

(1) A concentration on universal beams and columns which (*a*) are more efficient than the conventional beams they will replace ; and (*b*) reduce fabrication costs by permitting the substitution of plain for compound members.

(2) Lighter and more efficient joists in the smaller sizes.

(3) Channels, equal angles and unequal angles with square toes to facilitate welding.

(4) A general rationalisation permitting : (*a*) an improved cycle of rolling and therefore improved deliveries ; and (*b*) a reduction in stockholding.

As the issue of the new Standard may give rise to questions on the supply of current B.S. beams which will become non-standard, the steelmakers have issued a statement covering the overlapping period. They will make available for a period of at least twelve months all the conventional beams in the current B.S.4 : 1932 and all broad flange beams (as distinct from universals) in the current B.S.4B : 1959, which will become non-standard in 1962. As the demand for these beams will diminish, a continued supply beyond 1962 cannot be guaranteed. In the case of channels and angles no problems arise since the variations from the original standards are slight. The rolls for the non-standard beams will no doubt be available for a longer period, and requirements could be met provided that the orders for each section were sufficiently large to justify the mounting of the rolls.

Safe load tables based on the new Standard are being prepared, and should be available towards the end of 1962. The current safe load tables will be of service at least throughout 1962.

Several steelmakers now have plant for rolling universal beams and columns. Dorman Long (Steel) Ltd. has rolled a full range of these beams and columns since 1958, and the Appleby-Frodingham Steel Company and the Lanarkshire Steel Company Ltd. are now in production of universal beams up to 24in in depth and universal columns up to 12in by 12in. The South Durham Steel and Iron Company Ltd. will also roll the full range from 6in by 6in to 24in by 12in, commencing early in 1962. Shelton Iron and Steel Ltd. will do so later, but with a maximum of 16in deep in universal beams.

## International Apprentice Competition, 1962

A PRELIMINARY notice has been issued stating that arrangements are being made for the selection of a British team to take part in the 1962 International Apprentice Competition. The date and place of this competition, the eleventh in the series, have not yet been settled, but it is expected that an announcement will be made early in 1962.

The British Organising Committee for this competition was formed in 1956, when the City and Guilds of London Institute agreed to provide the necessary administrative and secretarial help. Since that time the size of the British team has increased from six in 1956 to thirty-one in 1961. Of these thirty-one, twelve entrants gained awards: two gold medals, seven silver medals and three bronze medals. Details of the procedure for selecting the British team and further information about the competition can be obtained from the Director (I.A.C.), City and Guilds of London Institute, 76, Portland Place, London, W.1.

## " Seaslug " Trials

THE Royal Navy's medium-range guided missile " Seaslug " is now ready for service with the Fleet. Years of development have culminated in a most successful series of acceptance trials from the Navy's trials ship, H.M.S. " Girdle Ness," off Malta. In the recent series of firings, 90 per cent of missiles intercepted the target, and had live warheads been fitted, the target would undoubtedly have been destroyed. The most outstanding aspect of this missile is said to be a reliability which is unmatched by any other missile in the world to-day. " Seaslug " has been subjected to the most rigorous environmental tests, including extremes of temperature, damp and vibration. It has been transported by sea and air to Malta, and has been fired by H.M.S. " Girdle Ness " at a wide variety of targets. In the final series of trials, radio-controlled " Canberra " aircraft at great heights have been used as targets, and on no occasion did the missile fail to intercept. Other successful firings have taken place at aircraft flying low over the surface of the sea. It is claimed that when it is embarked next year in the " County " class guided weapon destroyers, " Seaslug " will be the best shipborne surface-to-air missile at sea in the Western world.

During the five years H.M.S. " Girdle Ness " has been in commission since her conversion to her present role, she has fired hundreds of missiles. The success of the trials has been very largely due to the degree of co-operation established between the Royal Naval officers and ratings, members of the Royal Naval Scientific Service and civilians from industry who have been connected with the development of the weapon. Also perfected during the recent trials has been a system of missile maintenance. Personnel training has likewise received considerable attention, with the result that the ship's company will provide an invaluable nucleus of guided missile experience for the operational Fleet. The main contractors for the missile development have been the consortium of Whitworth Gloster Aircraft Ltd., G.E.C. Ltd. and Sperry Gyroscope Company Ltd. and E.M.I. Ltd. The ship's guidance radar sets were developed at the Admiralty Surface Weapons Establishment at Portsdown, Hants.

## Radio Communication Service for Vehicles

THROUGH relay centres in London, Birmingham and Bradford, a service known as " Air-Call " enables road users to communicate from their vehicles with any subscriber on the national telephone system, or with each other. Users rent mobile radio equipment which provides contact with the relay centres over a range of about 30 miles. The centres maintain a continuous listening watch and have the usual private branch exchange facilities for obtaining local or long-distance telephone calls. To conform with Post Office regulations, " Air-Call " users and their correspondents on the telephone system are not put in direct contact, but messages are relayed between them by the centre operators. When a call originates from an ordinary telephone, the operator broadcasts the call sign of the car to which it is addressed until the car answers.

Service in the London area is given from two transmitter/receiver sites, one at Hampstead and the other at Crystal Palace, linked to a relay centre in Wardour Street. Plans are in hand for extending the service beyond the areas served at present by the London, Birmingham and Bradford stations, beginning with a new centre in Manchester to be opened within a year. Equipment for the " Air-Call " system is distributed and installed by Bradley Industrial Business Machines Ltd., 529, Finchley Road, London, N.W.3. It consists of a Pye v.h.f. transmitter-receiver with a four-transistor power pack, operated from the normal car 12V battery, to provide h.t. for certain valves, although others operate with 12V on their anodes. There are three removable chassis in this equipment, one comprising the power-pack/modulator unit, the second the receiver, and the third the transmitter. The channel selector is motor-driven and operated by push-buttons on the dashboard control unit. A send-receive switch is incorporated with the hand microphone.

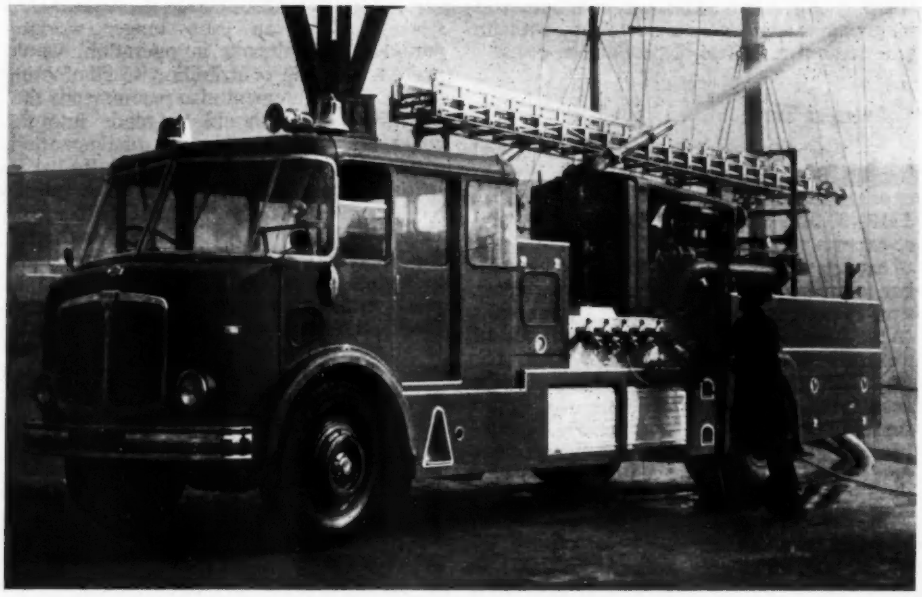
[Reply Card No. 1507]

## Centenary of Venezuelan College of Engineers

THIS autumn the Colegio de Ingenieros de Venezuela celebrated its centenary. In connection with this event a congress was held in Caracas during October 21 to 28. In addition to the proceedings of the Congress, there has now been published a commemorative issue of the College's journal *Revista*, with articles contributed by the various constituent societies, dealing with technological and allied developments in Venezuela.

## Relay Pumping Appliance

THE mobile relay pumping equipment illustrated on this page has been supplied by Merryweather and Sons Ltd., Greenwich, to the Hong Kong fire brigade. It is capable of pumping 2000 gallons of water per minute and its principal duty will be to take suction from the sea and pump the water through lengths of 4in canvas hose to keep the Island's emergency water tanks charged during a serious fire. The appliance will also serve as a fire-fighting unit and for such work the machine incorporates ten delivery outlets (five on each side of the vehicle) and two 4in monitors which are mounted in the appliance forward of the pumping unit.



Mobile relay fire pumping appliance

The equipment is mounted on an A.E.C. "Mercury" 16ft 3in chassis having a diesel engine developing 130 b.h.p. at 2200 r.p.m. The self-contained two-stage high efficiency turbine fire pump is directly coupled to a Rolls-Royce diesel engine developing 230 b.h.p. at 1850 r.p.m. This pumping set is mounted above the rear axle and is quite independent of the road engine. The pump is designed to deliver from 2000 g.p.m. at 100 lb per square inch maximum to 1000 g.p.m. at 170 lb per square inch.

The crew cab has ample accommodation for the driver, an officer and four men. Spacious locker space is provided for hose and miscellaneous gear, and the machine also carries a 45ft light alloy ladder and three wooden hook ladders.

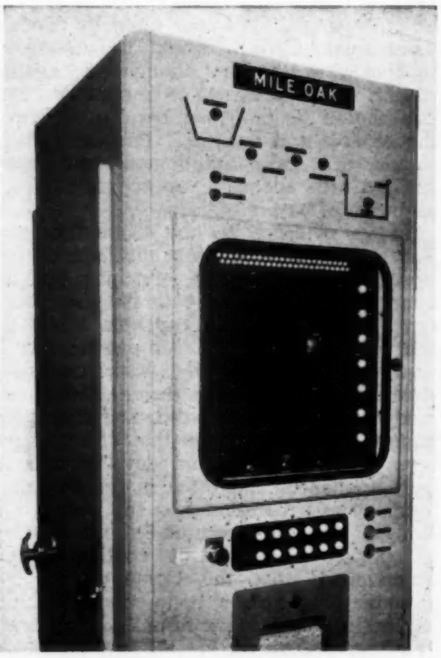
[Reply Card No. 1486]

## Remote Control of Pumping Station

THE latest stage in the modernisation of public water supply in the Brighton area came into service on December 15, with the opening of the fully automatic pumping station at Mile Oak. The control system, designed, manufactured and installed by Parkinson Cowan Measurement, 7-17, Fitzalan Street, London, S.E.11, enables the operation of six pumps at Mile Oak to be programmed and controlled from the Bond Street headquarters of the Waterworks Department, some five miles away.

Operating over two rented G.P.O. lines, the system enables any combination of six surface and well pumps to be started or stopped and, through a programmer, pump operating requirements over a seven-day period can be set up and stored. This enables the pumping plant to be used in rotation and the well draw-off planned in accordance with the known daily consumption. Pump operations are checked automatically every half-hour and at the same time any change in the pump combination programme is signalled to the Mile Oak station. Interlocks and timed delays are incorporated in the system to ensure balanced operation between the surface and well pumps as regards flow, pressure surges and allowance for passage of water through the sterilisation equipment.

Lights on a mimic diagram on the combined controller and programmer (illustrated), backed by audible alarms, give instantaneous indication of faults either at the pumps or elsewhere in the system. Programmes are set up by inserting plugs in the plugboard seen, in the illustration, below the mimic diagram. The principal possible faults catered for are low or high reservoir levels, fractured suction or delivery mains, pump overheating, power failure or low chlorine residual in the sterilisation plant. Subsidiary possible faults which are protected against include any discrepancy, at any time, between pump operations programmed and the actual pump conditions. For permanent records, the control panel at the headquarters incorporates a strip chart recorder with a time cycle of four months on which full pump running and stopped conditions are shown. While normal operating procedure is for the half-hourly signals to be transmitted from the programmer to the pumping station, it is also possible to transmit control signals by manual switching at any time.



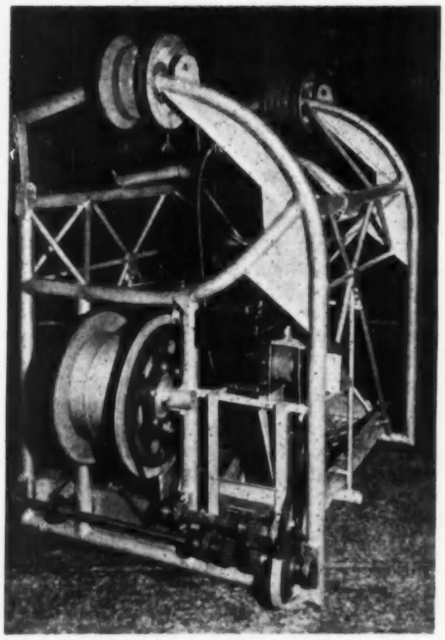
Combined controller and programmer for seven-day working cycles of six pumps

At the Mile Oak pumping station a control console enables local control to be exercised if required. This local control can operate either automatically—with full interlock functioning as in normal remote control—or manually by means of push-buttons. A more detailed mimic diagram than that at headquarters permits immediate and accurate diagnosis of any breakdown. For specified fault conditions the pumping plant is shut down automatically.

[Reply Card No. 1508]

## Power Line Inspection Trolley

A SPECIAL inspection trolley has been designed and built by the Bowthorpe Engineering Company Ltd., Gatwick Road, Crawley, Sussex, for use on the cables of the 5301ft transmission line span at the Severn crossing of the 275kV supergrid system to South Wales. The general design of this inspection trolley can be seen in the photograph we reproduce. It comprises a welded tubular steel frame with a two-man platform and a petrol-engine-driven winch. The cantilevered top members of the endframes are fitted with roller-bearing-mounted p.v.c.-covered aluminium wheels through which the trolley is supported from the conductor cable whilst working. As a safety precaution hinged sections on the uprights are clipped to the ends of the main arms whilst the trolley is working.



Power-driven trolley for inspecting overhead power transmission lines

The 1¾ h.p. petrol engine drives the winch through reduction gearing, chains and a dog clutch. Should the engine break down the dog clutch can be disengaged and a pedal drive engaged by which the passengers can operate the winch to haul the trolley back to the tower.

For operation the trolley is hauled up a tower and slung from the conductor cable to be inspected. The end of the winch rope is fixed to the tower and, at a speed controlled by the winch brake, the trolley runs down the catenary of the cable. At the conclusion of an inspection run, when the trolley reaches the bottom of the catenary, the winch engine is started and the drive engaged to haul the trolley back to the tower—where it can be transferred on to another conductor for the next inspection run.

[Reply Card No. 1484]

# INDUSTRIAL NEWS

### Engineers' Wages and Hours

The Engineering Employers' Federation has rejected the claim made by the Confederation of Shipbuilding and Engineering Unions on September 27 for an increase in the rates of wages of all adult male workers in the engineering industry, an increase for the women workers which would give the adult women the same minimum rate as the adult male labourer, and a reduction of hours of from forty-two to forty a week (The Engineer, October 6, 1961).

In a statement rejecting the claims, Mr. Macarty, director of the Employers' Federation, dealt in turn with the points raised by the Confederation in submitting its claim. The index of retail prices, Mr. Macarty said, had risen by 3·3 per cent between June, 1960, and June, 1961, while average earnings for all classes of workers covered by the Federation's survey increased by 6·7 per cent. Referring to the number of workers on minimum rates, Mr. Macarty said that since 1954 this number had been reduced enormously. There would always be the new starters, he said, the elderly men who were being retained in employment on humanitarian grounds, and other special considerations, as a result of which, for a time at any rate, some men would be remunerated on the minimum rates of any industry, and the minimum rates in engineering were not the lowest. Commenting on the Confederation's submission that real average weekly earnings had not risen as much as productivity in the industry during the last thirteen years, Mr. Macarty suggested that comparisons with average earnings in 1948 were not realistic. Past performance does not pay future wages, he added, and the amount that an industry could pay was entirely dependent upon its successful operation.

In reply to the claim that increases in wages should come out of profits and therefore not inflate costs, Mr. Macarty pointed out that if any of the industry's claims had been met in full in recent years, the sums of money required would have exceeded the total distributive profits, before tax, of the whole industry. In other words, if shareholders had received no dividend at all, meeting any of the claims in full would still have added to costs.

The Confederation had stated in its submission for a general wage increase that the belief that the Federation never yielded anything unless it was more or less compelled to do so was still one of the many factors bedevilling industrial relations. The Federation felt entitled to suggest, Mr. Macarty said, that if industrial relations were bedevilled, the continuous pattern of claims by unions, who appear to be quite insatiable, was perhaps the primary cause.

Dealing with the claim for a forty-hour week, Mr. Macarty pointed out that the Federation had several times said that history had shown conclusively that the length of the normal working week did not appear to bear any relation to the number of hours worked. In 1947, he said, the standard working week was reduced to forty-four hours. In 1960 it was reduced to forty-two hours. But in January, 1948, the average hours worked were 45·6, in June, 1960, 46·5, and in June, 1961, 46·7. The average number of hours overtime worked had increased from 1·6 in January, 1948, to 4·7 in June, 1961. It is obvious that actual working hours cannot be reduced under to-day's conditions, Mr. Macarty said, and that any concession to this claim would result in giving more overtime premium, with an automatic further rise of production costs.

### Overseas Trade

According to provisional figures issued by the Board of Trade, United Kingdom exports during November were valued at £319,400,000, imports at £373,800,000, and re-exports at £12,900,000. The monthly rate of exports in September, October and November, allowing for normal seasonal variation, was 1½ per cent less than in the four months May, June, July and August. The rate of exports in the first eleven months of the year was 4 per cent more than the average for the year 1960. On the same basis, the Board says, imports were 1 per cent more in September-November than in May-August, and in the first eleven months of the year were 3 per cent less than the average for the year 1960.

In September, October and November, monthly average re-exports amounted to £13,000,000 compared with £15,000,000 in May-August, but the monthly average for the first eleven months of this year was £13,000,000 compared with £12,000,000 in the year 1960.

### Major Ports of Great Britain

In a statement which has been submitted to the Rochdale Committee, the Government committee of enquiry into the major ports of Great Britain, the Federation of British Industries says that the ownership of ports should be based upon the Public Trust system, which would be non-profit making in the sense that, though a reasonable surplus should be earned on normal working, this should be ploughed back to improve the services and facilities. Port authorities should be locally autonomous and competitive with adequate, or majority, representation of payers of dues.

In its evidence to the Committee the Federation points out that the load on the ports is a developing one, changing both in quantity and character with the passage of time. The Federation expresses the hope that the Committee will map out the overall course for the future, but warns that port development cannot rest there. Continuous study of methods is needed, and this study cannot be divorced from that of the ships' own handling equipment, developments in port appliances and those in the transport field. The Federation sees the need for a body charged with research into the working of ports, the statement continues, and recommends that the Committee should examine how such a body can best be set up, both to look to the future and to ensure that the result of the best current experience in port operating, both at home and abroad, is widely disseminated to those who can profit by it.

Future port development should be directed to the major estuaries, the Federation states, particularly the Thames and Mersey, and with the increasing importance of the European Market, the cross-Channel ports which offer the most rapid transit for deliveries to Europe, at the least cost, including container and "roll on, roll off" facilities, also merit development.

There can be no doubt, the Federation says, that the introduction of a two-shift system, where an even longer working period is not already in operation, would make a very big contribution to eliminating delays. The statement also recommends that an investigation should be made into the wider use, and possibly the amalgamation, of the groupage services of British Railways, British Road Services and some public hauliers, and also the "Smalls" Reception Depot of the Port of London Authority, for delivery of small consignments to individual ships. Improvements should be made to the approach roads to the London Docks, the Federation says, and in particular to those in the immediate vicinity of the docks. The Committee is also recommended to examine proposals for relieving congestion in the Mersey Tunnel by the provision of more cross-river facilities, and for improving the access to Hull by means of a bridge or tunnel across the Humber to Hull. Heavy lift capacity should be increased, the Federation suggests, at practically all the major ports.

### Industrial Relations in the Shipbuilding Industry

A joint meeting of representatives of the Shipbuilding Employers' Federation and of the Confederation of Shipbuilding and Engineering Unions was held last week under the chairmanship of Mr. John Hare, Minister of Labour, to discuss ways in which industrial relations and efficient working would be improved in the industry. Mr Hare urged both sides of the industry to re-examine attitudes and practices which impaired its competitive efficiency. The industry could no longer afford strikes on the same scale as in the past, he said, nor could it afford the present wasteful use of skilled manpower due to lack of continuity in employment, and the way in which tasks were broken down between the various trades.

Mr. R. C. Thompson said that the employers were fully conscious of the importance of maintaining the standards of craftsmanship but felt that great improvements in the productivity of individual labour—and therefore in the competitive ability of the industry—could be achieved by greater flexibility in the use of labour ; some such measures were in fact an urgent necessity.

Pointing out that the trade unions were as anxious as the employers to improve the industry's competitiveness in world markets since their members' livelihood depended on it, Mr. E. J. Hill suggested that the situation in the industry was not so bad as it was sometimes painted. The unions would be ready to examine, on a reciprocal basis, any suggestions for improving the industry's position.

The Minister suggested that a working party should be set up under the chairmanship of Mr. P. H. St. John Wilson, deputy secretary, Ministry of Labour, to consider practical measures for improving relations in the industry and its competitive ability. The two sides agreed to this proposal.

# PERSONAL AND BUSINESS

## Appointments

George Kent Ltd. has appointed Mr. R. C. Ingram to the newly created post of marketing manager.

Mr. Michael J. L. Brook has been co-opted on to the board of Brook Motors Ltd. as production director.

Mr. F. A. Ramage, A.M.Brit.R.E., has been appointed technical sales manager of Electro Mechanisms Ltd.

Mr. Brian D. Hughes has recently joined Crompton Parkinson (Stud Welding) Ltd. as special projects engineer.

Mr. W. S. H. Whitehead has been appointed overseas marketing manager of G.E.C. (Domestic Equipment) Ltd.

Shawnee Poole Ltd. announces the appointment of Mr. J. A. Chapman as district representative for the southern area.

Mr. C. G. Ahlquist and Mr. J. V. Goddard have been appointed directors of Henry Simon (Holdings) Ltd. with effect from January 1, 1962.

Mr. H. C. Mayer, executive director and secretary of Griffin and George Ltd. and its subsidiaries, has been appointed deputy managing director of the group.

Mr. J. Arnold Needham has succeeded Mr. Frank Nattrass as technical sales engineer of the soils compaction division of Armstrong Whitworth (Metal Industries) Ltd.

Sir John Macpherson has been appointed chairman of Cable and Wireless Ltd. and its associated companies in succession to the late Sir Godfrey Ince. He will take up the post on January 1, 1962.

The Ministry of Aviation announces that Mr. Ritchie Campbell, M.I.C.E., has been appointed to the Scottish Advisory Committee for Civil Aviation in succession to Mr. J. C. Lang, who died earlier this year.

Sir Harry Melville, F.R.S., secretary of the Department of Scientific and Industrial Research, has been appointed to be a member of the Research Council (Council for Scientific and Industrial Research).

Mr. Reg Billington, M.I.E.E., has been appointed inspector of wireless telegraphy in the wireless telegraph section of the radio services department of the Post Office to succeed Mr. T. A. Davies who retires at the end of the year.

Turner and Newall Ltd. announces the appointment as consultant architect of Mr. E. D. Jefferiss Mathews, F.R.I.B.A., A.R.I.C.S. He will advise the company on all matters relating to design and application of products for use in the building industry.

Mr. V. R. Prehn, managing director of Ruston and Hornsby Ltd., is to retire on December 31 at the age of sixty-five. He is succeeded as managing director by Mr. C. T. Alderson, who since the beginning of this year has been deputy managing director.

Mr. P. G. Houchell, A.R.I.C., has been appointed chief chemist of the group research division of Pinchin Johnson and Associates Ltd. Mr. A. K. Unsworth, F.R.I.C., F.P.I., of the Pinchin Johnson Associates research division has accepted a senior technical post with a P.J.A. subsidiary company, S.p.A. Vernici Italiane Standard, of Milan.

Mr. Frederick William Tomlinson, M.I.E.E., F.I.M., has been appointed chairman of Pyrotenax Ltd. on the retirement of Sir Brograve C. Beauchamp, Bt., on completion of twenty-five years' service in that capacity. Mr. Tomlinson will continue to hold the position of managing director of Pyrotenax Ltd. as well as his directorships of the Pyrotenax Subsidiary Companies in Canada and Australia and of Giles and Elliott Ltd., New Zealand.

Mr. H. E. Cubitt is to become chairman of Holland & Hannen and Cubitts Ltd. on January 1, 1962. He succeeds Lord Ashcombe who, after thirty-two years as chairman, becomes president of the company. Mr. E. R. Hole, M.I.Struct.E., is to become deputy chairman, succeeding Sir John Keeling, who will retire from the board. Mr. P. A. Hannen and Mr. J. A. B. Keeling, who have been alternate directors, become full directors of Holland & Hannen and Cubitts Ltd. Mr. J. Eric Harrington, president of Canada's Anglin-Norcross Corporation Ltd., joins the board of directors, together with three directors of Cubitts' operating company in Great Britain, Mr. J. M. Harris, its managing director, Mr. P. Wyatt and Mr. T. O. W. Newman.

## Business Announcements

Aiton and Co. Ltd. announces that Mr. Leapingwell has resigned from the board of directors with effect from November 20.

Fielden Electronics Ltd. states that its London office has moved to 181-183, Earls Court Road, London, S.W.5 (telephone, Freemantle 7866).

Mr. Arthur Sykes, M.I.Mech.E., M.I.Prod.E., director and technical consultant to David Brown Industries Ltd., retired at the end of November after fifty-six-and-a-half years with the organisation.

The Press and Shear Machinery Company ltd., 172-178, Victoria Road, Acton, London, W.3, is to hold a demonstration of the latest types of its range of sheet metal working and forming machinery at its showrooms from February 5 to 16, 1962.

Martindale Electric Company Ltd. announces that several departments have moved into new offices at Movitex House, 6, Empire Way, Wembley. The company's design and production department will continue to occupy the existing Martindale premises in Westmorland Road and Lowther Road, Queensbury, N.W.9.

Thos. W. Ward Ltd. states that the entire share capital of James Shortland and Co. Ltd., nail manufacturers, Thistle Nail Works, Wishaw, has been acquired by John Williams (Wishaw) Ltd., a member of the Thos. W. Ward Group. Mr. W. Hall has succeeded Mr. W. N. Shortland as chairman and managing director, and Mr. Adam Parkin has been appointed director and secretary.

George Meller Ltd., 24, Fitzjohn's Avenue, London, N.W.3, informs us that it has become the sole United Kingdom representative and agent for Coppus Engineering Corporation of Worcester, Mass., U.S.A., makers of vertical and horizontal steam turbines from 1 h.p. up to 250 h.p. Our apologies are due for certain misspellings in a previous announcement in our issue of November 10.

Pollard Ball and Roller Bearing Company Ltd. has announced the formation of Pollard Ball and Roller Bearing Corporation in New York with registered offices at 521, Fifth Avenue. Mr. F. W. Herlitz, director of the Western Steel International Corporation, has been appointed resident director. Mr. John L. King, chairman of Pollard Ball and Roller Bearing Company Ltd., will be president.

Babcock and Wilcox Ltd. announces that Mr. J. F. Towell has been appointed resident engineer for the company at Sizewell nuclear power station, Suffolk. Mr. Towell will be responsible for the erection of the heavy mechanical engineering plant being supplied by the company in the construction of the 580MW nuclear power station, now being built by the English Electric Company Ltd., Babcock and Wilcox Ltd., and Taylor Woodrow Atomic Power Construction Company Ltd., for the Central Electricity Generating Board.

Crittall Manufacturing Company Ltd. has announced that a new factory to manufacture Crittall standard metal windows in Malaya will be in production before the end of the year. A new company, Crittall (Malaya) Ltd., has been formed and the new factory, in addition to manufacturing standard metal windows, will assemble purpose-made aluminium windows and curtain walling made in Britain. The factory is located at Petaling Jaya, Malaya's first industrial estate, 7 miles west of Kuala Lumpur. Sales and distribution remain in the hands of William Jacks and Co. (Malaya) Ltd., who will continue to hold stocks of standard windows and Fenestra Louvres for immediate delivery.

Hadfields Ltd. announce that negotiations have been concluded as a result of which Escher Wyss Ltd., Zurich, Switzerland, has purchased from Hadfields Ltd. 3,051,451 ordinary stock units of 2s. 6d. each of Millspaugh Ltd., Sheffield, for £1,200,000. This stockholding amounts to 60 per cent of the total issued ordinary stock capital of Millspaugh Ltd., and, therefore, that company is no longer a subsidiary of Hadfields Ltd. However, Hadfields Ltd. continues to hold approximately 33 per cent of the Millspaugh equity and will be represented on the board. In parallel, agreement has been reached, subject to Treasury approval, for the Black-Clawson Company of the U.S.A. to purchase certain Canadian manufacturing interests which, as far as Millspaugh is concerned, have shown a bad past experience. Arrangements will be made for representation to be maintained in Canada by both Hadfields and Millspaugh.

## Contracts

W. and J. R. Watson is to construct four-and-a-half miles of the Invershin-Ledmore-Lochinver road (A.837) at an estimated cost of approximately £170,000. The Sutherland County Council prepared the scheme and will supervise its execution.

British Aircraft Corporation is negotiating a contract to supply a "substantial number" of Vickers "Vigilant" one-man, wire-guided anti-tank missiles to the Army for use both by infantry and reconnaissance (armoured car) units of the Royal Armoured Corps. The weapon was described and discussed on July 13, 1961, page 63.

Stothert and Pitt Ltd. has been awarded a contract for the supply of the blast-furnace slag processing plant at the new Spencer Works, Newport, of Richard Thomas and Baldwins Ltd. The plant has been designed to deal with slag at a rate of 350 tons an hour at first, and to be capable of extension to handle 700 tons an hour. It will incorporate equipment for producing coated macadam at 120 tons an hour.

Butters Bros. and Co. Ltd., McLellan Street, Glasgow, S.1, has received the contract from the Firth of Clyde Dry Dock Company Ltd. for the supply of the four level-luffing dockside cranes for the new graving dock at Greenock. The contract is for the supply of two 60-ton and two 15-ton electric travelling level-luffing cranes. The 60-ton cranes will be capable of lifting the full load at 125ft radius to a height of 160ft above the track level. At the maximum radius of 185ft they will lift loads up to 20 tons. The 15-ton cranes, of generally similar design, will be capable of lifting 15 tons to a height of 160ft at 135ft radius.

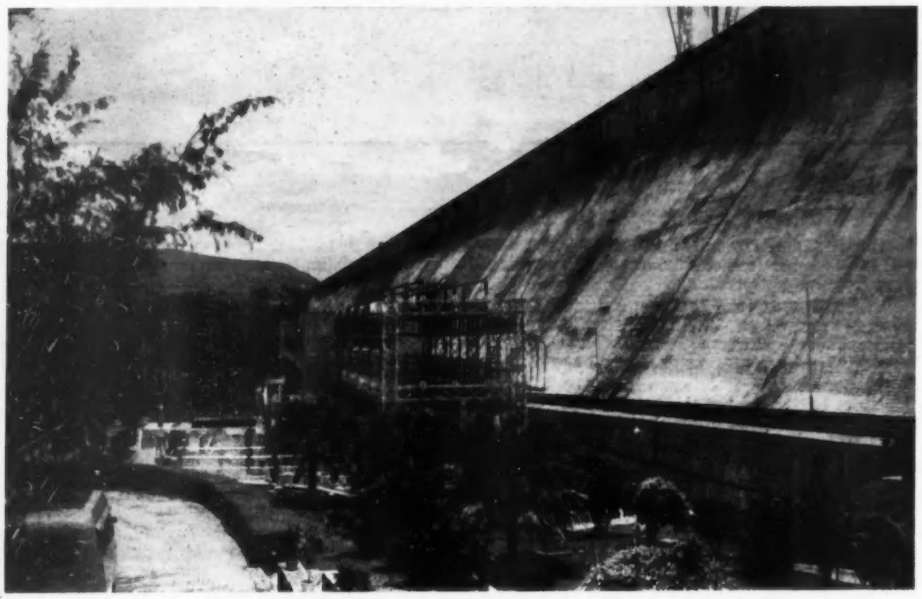
W. H. Allen Sons and Co. Ltd., Bedford, announces that it has received an order for four 27in vertical-spindle, double-suction, centrifugal circulating-water pumps from Aiton and Co. Ltd. on behalf of the Central Electricity Board, Federation of Malaya. The pumps, which are for the Johore Bahru Power Station, will each have a duty of 13,000 gallons per minute against a total head of 34ft when running at 585 r.p.m. Each pump will be close-coupled to 175 h.p., 3·3kV Allen totally-enclosed, fan-cooled, squirrel-cage motors. The consulting engineers for this contract are Messrs. Preece, Cardew and Rider, 8-10, Queen Anne's Gate, Westminster, S.W.1.

Newton Chambers and Co. Ltd., Thorncliffe, Sheffield, states that an order has been placed with NCK-Rapier Ltd. by the East Pakistan Water and Power Development Authority for fifteen crawler-mounted draglines and three truck-mounted cranes, valued at over £260,000. The machines are being purchased through a United Kingdom loan to the East Pakistan Government and are the first to be sold to East Pakistan from this country for several years. NCK-Rapier Ltd., 32, Victoria Street, London, with which the order was placed, is the selling organisation for the excavators and cranes made by Newton Chambers and Co. Ltd. and by Ransomes and Rapier Ltd., Ipswich.

## Deaths

We regret to record the death, on December 1, of Mr. Laurence Edgar. Mr. Edgar joined John Thompson Ltd., Wolverhampton, in April, 1955, as group publicity manager, and built up a department to serve John Thompson Group Companies in all branches of publicity. Some three years later, ill health prevented him from continuing in a full-time capacity, but he was able to work on special assignments. Before joining John Thompson Mr. Edgar had served as assistant publicity manager for the Daimler Motor Company, and publicity manager for Kensitas. During the second world war he served in the Royal Engineers, and was awarded the Military Cross.

We regret to record the death on December 2 of Mr. John Waddell, who had been associated with the D.P. Battery Company Ltd. since its foundation in 1895, retiring from the chairmanship in 1956, although remaining on the board. Mr. Waddell assisted with the pre-production tests of the first D.P. batteries between 1888 and 1895, and when manufacturing premises were acquired at Bakewell in 1898 he assisted in installing the plant. From 1900 to 1961 he was continually at Bakewell, successively as works manager, general manager, managing director and chairman of the company.



**Dam and power station at Mettur**

# Power Progress in Madras State

By OUR INDIAN CORRESPONDENT

THE Madras power grid at present covers all the districts of the State and consists of seven hydro-electric and two thermal power stations with a combined capacity of 501,750kW ; 14,700 miles of high tension transmission lines of voltage ranging from 11,000 to 230,000V ; 21,600 miles of low tension distribution lines and 140 e.h.t. and h.t. substations and 9724 distribution and transformer stations. The capacities of individual power stations are :—

| | |
|---|---|
| Hydro-electric : | |
| Pykara ... ... ... ... ... ... | 70,200kW |
| Moyar ... ... ... ... ... ... | 36,000kW |
| Mettur ... ... ... ... ... ... | 40,000kW |
| Papanasam ... ... ... ... ... | 28,000kW |
| Periyar ... ... ... ... ... ... | 105,000kW |
| Kundah No. 1... ... ... ... ... | 40,000kW |
| Kundah No. 2... ... ... ... ... | 70,000kW |
| Thermal : | |
| Madras ... ... ... ... ... ... | 98,500kW |
| Madurai ... ... ... ... ... ... | 14,000kW |
| Total... ... ... ... ... ... | 501,700kW |

This grid is serving electricity to 735,000 consumers, nearly 80 per cent of them directly served by the Madras State Electricity Board and the rest through five municipal and eight private licensees. The aggregate peaks of the system in 1960 was 460,000kW while the coincident peak of the grid was approximately 400,000kW. Power generation during the year was some 1,903 million units of which 76 per cent was from hydro-electric power and the balance from coal. The total capital invested to the end of March 1961 was around Rs. 132.88 crores, and the annual gross revenue during 1960–61 exceeded Rs. 16 crores.

Real power progress in Madras dates from 1925 when the Government initiated a policy of active development of the power reserves by the State. The first hydro-electric scheme (the Pykara project) was taken up in 1929 and completed in 1937. The Papanasam power house was commissioned in April, 1944. The first thermal station to be erected by the State Electricity Department was brought into operation in 1951 at Madurai.

During the first Five Year Plan activity in the electricity field was confined to the construction of a new power house at Moyar and extensions to existing stations at Pykara, Papanasam, Madurai and Madras. The installed generating capacity increased by nearly 65 per cent from 156,000kW to 256,700kW. The third stage extensions at Madras comprising 30,000kW were completed in April, 1958 and the Periyar hydro-electric scheme in October of the same year. The first power station under the Kundah hydro-electric scheme came into operation in March, and the second station in October, 1960. The final outlay on power schemes of the State during the second Five Year Plan will be approximately Rs. 71.31 crores, which on completion will more than double the installed generating capacity, length of lines and the number of towns and villages electrified :

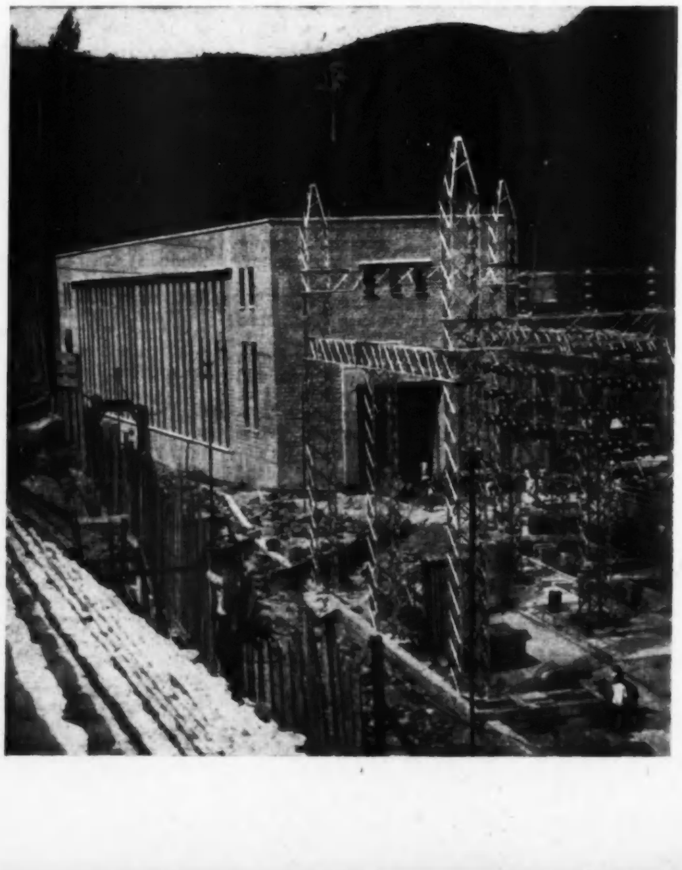
| | 1955–56 | 1960–61 | Percentage increase |
|---|---|---|---|
| | kW | kW | |
| Generation ... ... ... ... | 256,000 | 571,000 | 123 |
| Units generated (in millions) | 1,055 | 2,500 | 136 |
| Transmission (H.T. lines 11kV and above) ... ... | 7,343 | 15,500 | 112 |
| Distribution (number of villages and towns electrified) | 3,543 | 10,000 | 183 |

The Madras plant extensions (III stage), which envisaged the erection of a 30,000kW set, with two 150,000 lbs per hr. boilers, were completed in April, 1958 ; the first unit of Periyar hydro-electric scheme in October 1958, the second unit in February, 1959 and the third in May of the same year, adding 105,000kW installed generating capacity to the grid.

The first unit in plant No. 1 of Kundah hydro-electric scheme was completed in March, and the second in June, 1960. The first unit in plant No. 2 of this scheme had been in operation since October, 1960. The Kundah power station No. 2 was formally inaugurated on January 18, 1961 by Mr. Gordon Churchill, Minister for Veterans Affairs, Government of Canada. The second unit in power house No. 2 was started up last January and the third unit will be commissioned before the end of this year.

Including the transmission lines proposed under the Kundah and Periyar schemes an additional 8200 miles of e.h.t. and h.t. lines and 12,000 miles of l.t. lines were erected during the second Plan period. The first 230kV line from Kundah to Madras was completed recently. It conveys power generated at Kundah to Madras a distance of some 300 miles. Madras continues to maintain its lead in the matter of rural electrification with 10,370 towns, villages and hamlets electrified in January 1961. It is estimated that nearly 6200 villages and hamlets enjoyed the benefits of electricity during the second Plan period and 112,560 pumpsets worked on electricity at the end of the period. To meet the rising demand for power during the third Plan schemes, computed to cost Rs. 100.19 crores, have been drawn up to more than double the installed capacity at the end of the second Plan. Also 8000 additional villages in the interior will get the benefits of electricity apart from 75,000 agricultural pumpsets. Preliminary work on the major hydro-electric schemes included under the third Plan (Mettur tunnel hydro-electric scheme and Kundah hydro-electric extension project) has already been started in 1960–61.

To-day Madras State ranks third in India in generation and utilisation of power after Bombay and West Bengal. Judged by the number of consumers, consumption and connected load it stands first in respect of utilisation of power for agricultural purposes. In the matter of hydro-electric output Madras is second only to Bombay. With the completion of the Kundah hydro-electric scheme Madras will lead in hydro-electric output. While the bulk of the power in Bombay and West Bengal is consumed by industries and urban loads Madras has built up an electricity grid extending into almost all the districts and rural areas.



**Power house No. 1 of Kundah hydro-electric project**

# CONTINENTAL AFFAIRS

*by Our Continental Editor*

## Urban Motorway at Duisburg

*The city of Duisburg, which has grown out of a number of small townships whose main line of traffic lay at right angles to the River Rhine, is at present carrying through a major motorway project with the aim of easing the flow of traffic in a direction parallel to the river. The article describes the north–south motorway of which the most important stage, the* 1824*m long Berlin Bridge, is now under construction.*

A MAJOR project now in the course of realisation—it involves the construction of the longest road viaduct in the German Federal Republic—is that of the north–south urban motorway at Duisburg, of which some important sections have already been completed. The motorway is designed to connect with the main road to Düsseldorf just south of Huckingen and, after traversing the centre of Duisburg, to continue through Meiderich and Hamborn with Walsum, a total length within the Duisburg urban area of about 23km. The need for this development is seen from a glance at the map (Fig. 2). The present City of Duisburg comprises a large number of originally separate townships which since the turn of the century have grown so as to form an almost continuous built-up area. However, as may be seen from the direction of the railway lines and canals, the main direction of traffic was east–west, between the hinterland and the river Rhine, following in this the line of the tributaries Ruhr and Emscher. North–south traffic, which in the nineteenth century was of lesser importance, has in recent decades grown to an extent where it threatened to paralyse communications within the city. The idea of a north–south through road and/or local railway (Schnellbahn) was mooted even before the First World War and again in the 1920s and early 'thirties. Although some relief with respect to long-distance traffic was obtained from the autobahn which skirts the area to the east, the situation at the beginning of World War II had become so critical that the overall project for an urban motorway was definitely decided on. The war and its aftermath, however, brought the matter to a complete standstill, except that no new building was allowed on land reserved for the road. In 1948, design work was taken up again, and the motorway was made part of Duisburg's economic plan in 1952.

In 1957 the Urban Motorway was incorporated in the Town Plan. It is designed as a dual carriageway for a traffic speed of 80 km.p.h. The overall width of 25m comprises two 7·5m wide two-lane roadways flanked on either side by a 0·5m wide surfaced shoulder, a central reservation 4m wide, and two outer grass shoulders. Buildings are prohibited within 20m of the motorway which is routed either above or below ground level and joined to the rest of the road system every 2km to 3km.

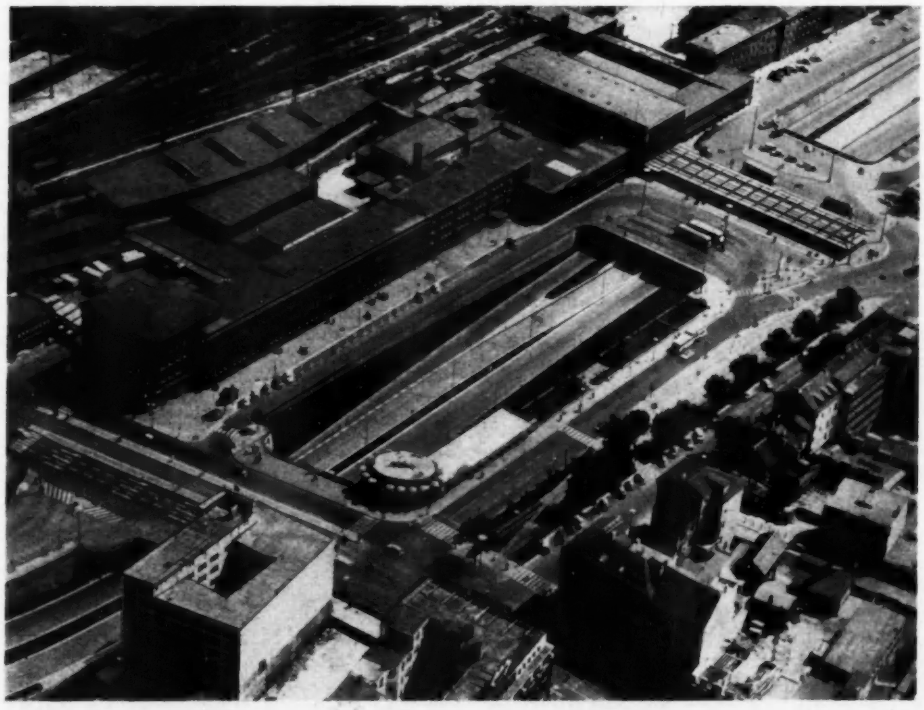
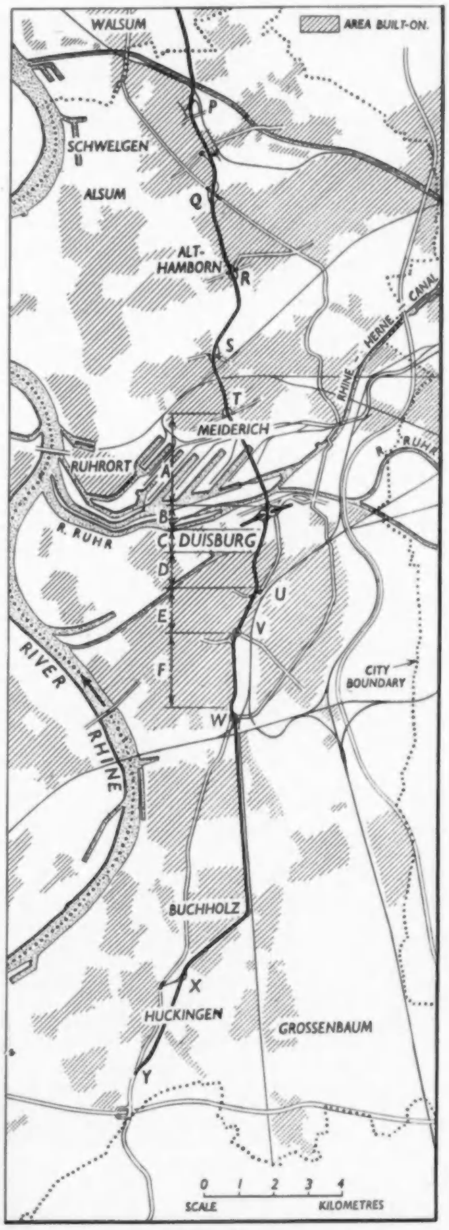


**Fig. 1—Motorway crossing forecourt area of main station below street level. This possibility was provided for when the station was built in 1932**



Junction with existing roads:

*P*—Prinz-Eugen-Strasse.
*Q*—Zinkhüttenplatz.
*R*—Beecker-Strasse.
*S*—Gartsträucher-Strasse.
*T*—Bürgermeister-Pütz-Strasse.
*U*—Landfermann-Strasse.
*V*—Kolonie-Strasse.
*W*—Grunewald.
*X*—Sittardsberg.
*Y*—Southern City boundary junction.

**Fig. 2—Layout of north-south motorway, showing sections at present under construction (*A* to *D*) or completed (*E* and *F*). The Berlin Bridge (total length 1824m) is at *A***

Specifications include a minimum inside radius of 250m (25m in approaches) and minimum hump or dip radii of 5000m (1000m in approaches). Curves of 3000m radius or less are to have clothoidal transitions and intermediate straight sections are to be avoided. Gradients may not exceed 4 per cent anywhere.

## CONTINENTAL AFFAIRS *(Continued)*

At junctions, 3m wide acceleration and deceleration lanes are incorporated, the former with a minimum length of 180m, the latter with one of 120m. The main roadway is being surfaced with black top, while the approaches are paved so as to distinguish them visually. All bridges are in loading classification 60, according to DIN-standard No. 1072. Surface drainage is provided throughout. The motorway is lit by twin-armed masts on the central reservation.

The section between kilometres 8·400 and 10·460 (*F* and *E* in Fig. 2) which traverses the centre of the city has already been commissioned. Fig. 1, which shows the motorway passing the main railway station, gives an impression of this part of the road.

A further 1·2km, including a 372m long flyover crossing of the harbour railway yards, are nearing completion (*C* and *D* in Fig. 2) North of this portion lies the cloverleaf junction (*B*) with the Ruhr motorway which will underpass the Duisburg motorway at this point.

This junction which is to be completed in the spring of 1962 is followed by what will be the longest viaduct in Germany, the Berliner Brücke (Berlin Bridge) which will have a length of 1824m. It is marked *A* in Fig. 2, while Fig. 3 shows a photograph of the model, looking towards the north.

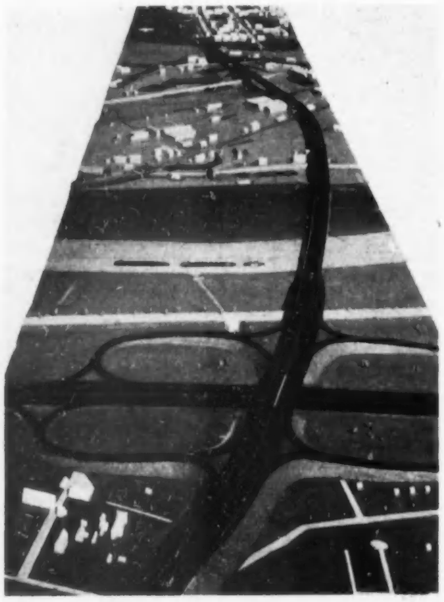


**Fig. 3—Model of Berlin Bridge looking towards the north. In the foreground, junction with Ruhr motorway, followed by Rhine-Herne canal, an industrial area, harbour basin, railway installations and a municipal park. The total length is 1824m**

The Berlin Bridge, which was begun in July, 1960, is to be commissioned early in 1963. It comprises thirty spans grouped in six main sections as may be seen from the accompanying table.

TABLE—*Berliner Brücke (Duisburg)*

(*Spans in metres. Figures marked * are transition sections.*)

| Section | |
|---|---|
| 1. Dyke ... ... ... | 23·0 +3·5* |
| River Ruhr ... ... | 90·0+150·0+104·05 +3·0* |
| 2. Rhine–Herne Canal | 66·15+84·8+65·18+3·0* |
| 3. Industrial district ... | 80·82+72·05+83·31+77·14+3·0* |
| 4. Harbour ... ... ... | 69·5+132·1+69·5+3·0* |
| 5. Railway station ... | 75·1+80·3+88·7+67·2+3·0* |
| 6. Municipal park ... | 22·4+nine spans 27·8 each+28·5 +25·6 |

After bridging the Ruhr dyke by a 23m long prestressed concrete span, the bridge continues over the Ruhr and its forelands in three steel spans of 90m, 150m and 104·05m. Then follows the crossing of the Rhine–Herne Canal in prestressed concrete with spans of 66·15m, 84·80m, and 65·18m, and the continuation in a similar manner with spans of 80·82m, 72·05m, 83·31m, and 77·14m over the industrial area between the canal and Basin " C " of the port of Duisburg-Ruhrort which together with its banks is crossed by a steel bridge with a central span of 132·1m and two side spans of 69·5m each. A further five steel spans (75·1m, 80·3m, 88·7m, and 67·2m) cross the sidings of Ruhrort–Hafen railway station, after which the bridge is carried over the Meiderich municipal park in twelve prestressed concrete spans, comprising one span of 22·4m, nine spans of 27·8m, and two spans of 28·5m and 25·6m respectively.

The spans in the individual sections are continuous, with 3m long transitions between sections. One major complication arises from the fact that the bridge crosses a coalfield in which subsidence due to mining operations is expected to occur for the next ten to fifteen years. This makes it necessary to incorporate means for making corrections at the intermediate piers, using the end piers of each section as points of reference. Because of the considerable length of the sections (about 300m), any differences in settlement between the ends will not to any important extent affect the vertical profile of the bridge. In this way the economy of continuous spans is achieved and the number of expansion joints is kept low.

With the exception of those of the park section, all the piers are free-standing. While the intermediate piers in each section are hollow, the piers common to two neighbouring sections are solid and broader, with sides carried up to railing level. In this way the expansion constructions are hidden, and the transition between girders of different heights or materials is less noticeable. Each common pier is fitted with a fixed bearing at the south side and a movable bearing on the north side, with the exception of the pier on the Ruhr dyke which has two movable bearings. Chiefly because of changes brought about by mining subsidence, the transition constructions have to allow for movements of up to ±0·90m.

Because of the threatening subsidence, but also because this makes for an easier and more economic construction, the bridge is being built with two separate superstructures, one for each carriageway. As elsewhere, the total width provided for in each direction is 8·5m, consisting of a 7·5m wide carriageway for two lanes of traffic and 0·5m wide shoulders on each side. The inner and outer edges are protected by a kerb and a 0·46m high guard wall or rail of the same material as the respective bridge section. Along the outside of either superstructure is a 0·98m wide footpath ; the gap between the two halves of the bridge is covered over by a light deckplate permitting mutual movement and tilt. Cantilever brackets carry the centrally positioned lighting masts.

For the concrete spans, the nominal cross section of each half is a box 3·5m deep and 6·3m wide while the deck—excluding the structurally separate footpaths and central reservation—overhangs by 1·77m on either side. The concrete thicknesses are : deck, 0·24m, sides, 0·38m, bottom, 0·15m. In the case of the sections over the Rhine–Herne Canal and the industrial area, the depth of the box girders is 3·67m. The concrete bridge over the park has twelve spans with a constant depth of 1·37m. This section does not consist of separate halves, but the deck forms a single plate extending over two box sections. This gives it sufficient lateral resistance so as to be able to transmit wind forces at the abutments. In this way intermediate piers are relieved of transverse loads so that at each plane of support two columns are adequate to carry the vertical loads. These columns are fixed in the superstructure and at the base can move horizontally in any direction on double roller bearings.

The steel bridges again have separate superstructures, in the form of an 8·5m wide orthotropic deck resting on two vertical cross-braced plate girders spaced 5·5m apart. Footpaths and central reservation are cantilevered, or cantilevered and suspended from the main superstructures. The bridge also carries storm drains and gas and water mains. Certain of the spans, whether concrete or steel, which cross railway installations or waterways, are being constructed as cantilevers.

*Quantities.*—For the steel bridges a total of 7700 tonnes of rolled and cast steel will be required. Approximately 1250 tonnes of " ST 80/105 " prestressing wires and 1650 tonnes of plain reinforcement steel are being used in the concrete superstructures and in the piers and foundations. The total amounts of cement and aggregate will be, respectively, 12,500 tonnes and 40,000 cubic metres.

DESIGN AND MAIN CONTRACTORS

Overall planning and supervision : Amt für Brücknen- und Ingenieurbauten, Duisburg.

Superstructures (steel) : Demag A.G., Duisburg ; Rheinstahl Wanheim, Duisburg.

Superstructures (prestressed concrete) : working group comprising Dyckerhoff & Widmann K.G., Düsseldorf ; Ph. Holzmann A.G., Duisburg ; Ed. Züblin A.G., Duisburg.

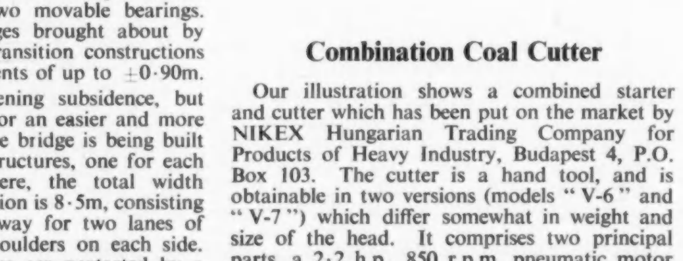
Foundations, piers, abutments and dyke bridge superstructure : working group " Nord-Süd-Strasse " (Brüggemann–Fischer–Hitzbleck) ; working group " Pfeilerbau Berliner Brücke " (P. Fix Söhne–W. Graas–Jaeschke & Preuss–Reg. Baumstr. R. Schulze–Vollrath).

## Combination Coal Cutter

Our illustration shows a combined starter and cutter which has been put on the market by NIKEX Hungarian Trading Company for Products of Heavy Industry, Budapest 4, P.O. Box 103. The cutter is a hand tool, and is obtainable in two versions (models " V-6 " and " V-7 ") which differ somewhat in weight and size of the head. It comprises two principal parts, a 2·2 h.p., 850 r.p.m. pneumatic motor weighing 9 kg and consuming 1·7 cubic metres of air per minute at 5–6 atmospheres gauge ; and a breaking tool connected to the motor by a collar. The latter consists of two cutter heads counter-rotated by bevels from a central shaft on which is mounted a drill head. The speed of the cutters is given as 265–285 r.p.m. Model " V-6 " has five cutters set on pitch diameters ranging from 80mm to 180mm, while Model " V-7 " has eight cutters on 100mm to 152mm pitch diameters.

Rated breaking performances per cubic metre are claimed to be : friable black coal ten to fifteen minutes ; brown coal, twenty to thirty minutes ; Fuller's earth, fifteen to twenty minutes ; fireclay, thirty to forty minutes. In taking down strongly dipping seams, the nominal rate is stated to be substantially exceeded. Other applications include kerfing in order to save explosive.

[Reply Card No. 1439]



**Compressed - air - operated breaker, designed to be used as a combined starter and cutter**

# THE AMERICAN SCENE

*By Our American Editor*

## Homer Research Laboratories of the Bethlehem Steel Company

*The formal dedication took place on October 9 of the Homer Research Laboratories of the Bethlehem Steel Company at Bethlehem, Pennsylvania. Occupying a total of 475,000 square feet of floor area on a 1000-acre site atop a mountain, the laboratories are amongst the largest and most comprehensive in the American metallurgical industries. The laboratory divisions include process metallurgy, chemical engineering, mechanical engineering, ceramics, physical metallurgy, chemistry, physics and mechanics.*

ONE of the major research laboratories in the American steel industry was formerly dedicated on October 9 by Mr. Arthur B. Homer, the chairman of the Bethlehem Steel Company. Named Homer Research Laboratories in his honour, the facility is situated on about seventy-five acres of a 1000-acre site atop the South Mountain in Bethlehem, Pennsylvania. The five main structures are clustered around an attractive, but functional cooling pond. The buildings are all framed in structural steel and faced with Indiana limestone and random ashlar. A total of 475,000 square feet of floor area is provided.

After a tour of the buildings, the visitors attending the dedication heard Mr. Homer speak on a wide range of research activities scheduled for the new laboratories, including the development of a special new alloy steel which shows great promise in meeting the exceptional high-strength requirements of space vehicles. He said that while new products attract the most glamour, as much or more emphasis will be devoted to the preparation of raw materials and to the steelmaking process itself. He suggested, for example, that the next ten years might bring about much greater instrumentation and the use of automatic controls to keep pace with refinements in the actual steelmaking process. He also predicted an increase in automatic controls at the rolling mill stage. "As to the steel itself, the three important requirements are strength, durability and low cost. Steel can be made to have the highest strength of virtually any material. Also, it can be made to have excellent corrosion resistance. However, under present practice it is expensive to produce steel which attains the highest levels of strength and durability. Our problem, then, is to impart these two qualities to a greater extent to the low-cost tonnage products. It is a great challenge with great possibilities." Among other possible developments, Mr. Homer mentioned structural steels which may develop into a whole new family of steels, new high-strength steels for tonnage products such as shapes and plates, new kinds of coated or alloyed steels able to resist a wide range of corrosive conditions, processes by which metals like chromium, titanium, aluminium and others are actually diffused into the surface layers of sheet steel, and methods to combine plastic compounds and steel.

Although it may be said that research activity on an informal basis began with the start of its operations, a formal programme began in 1926 with the establishment of a Development and Research Department by the Bethlehem Steel Company. Two important early accomplishments prior to 1926 were the development of high-speed tool steel at Bethlehem around the turn of the century, and the improvement and development of the wide-flange beam which, for many years produced only by Bethlehem, helped to make possible to-day's skyscrapers.

After 1926, a number of important Bethlehem developments came rapidly. Controlled cooling of rails made possible safer and faster rail travel with high axle loads. Electrolytic coatings for wire and tinplate greatly increased the utility of these and other products. Production of free-machining steels of Bessemer grades in the open-hearth furnace both improved the quality and lowered the costs of such steels. Automated spectrographic analysis of steel still in the open-hearth furnace increased quality and lowered production time.

Homer research laboratories complex atop the South Mountain in Bethlehem, Pennsylvania

### LABORATORY DIVISIONS

The process metallurgy division of the research department covers the very heart of the business—the making of iron and steel, with the aims of greater productivity, lower costs and better quality. Much of the division's work is necessarily done in the steel works themselves, but the Homer Laboratories now provide a building housing pilot plant equipment. Included are a 3-ton electric arc furnace, three air-induction furnaces, and a vacuum-induction furnace, as well as offices and laboratories. A consumable-electrode furnace is being planned.

The highly diverse interests of the chemical engineering division range from coal, coke, and coal chemicals to fuels, combustion, lubrication, and waste control. Chemical engineering has been vital in many of the changes made in the transition to modern plant operations. In a modern mill, coke works use saturators and evaporators, for example. Much research work relates to coal chemicals, which are important by-products of the industry, and waste materials, which are treated or trapped to prevent pollution.

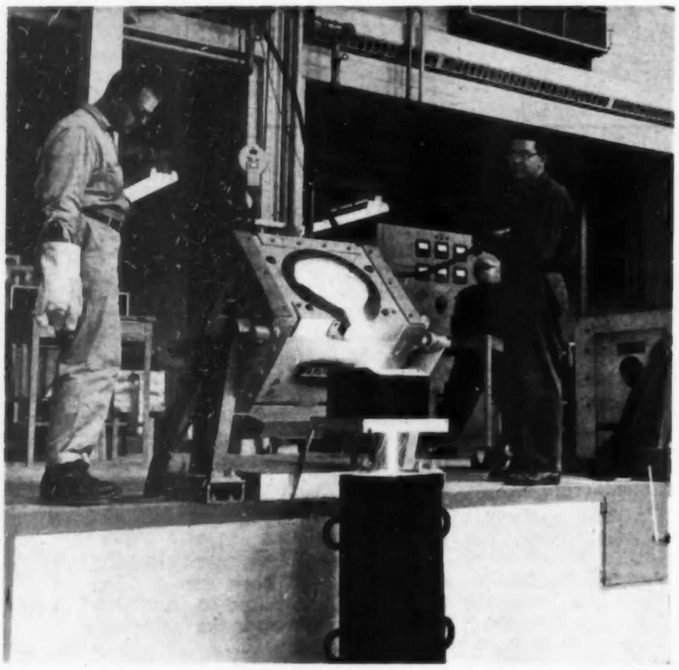
The mechanical engineering division is concerned mainly with the mechanical equipment used in steelmaking, since the properties of many steel products are influenced by the working of the metal in the producing mills. The improvements that can be made to existing equipment and the development of new mechanical equipment and techniques are the aims of this division. Highly specialised equipment for special jobs, such as continuous hot-dip galvanising, fall in this category.

The activities of the ceramics division centre on refractories. Bethlehem research in ceramics, for example, has helped to prove that there are enormous differences in the durability of various silica refractories. To-day, refractories are purchased according to rigid specification to ensure high efficiency in furnace operation. Other interests of this division are sintering and pelletising of ores, as well as heating-up procedures in blast furnaces, open-hearth furnaces, and coke ovens.

The physical metallurgy division is concerned with the mechanical and physical properties of steel and steel products, and how and why these properties are affected by heat treatment, the addition of alloys, mechanical working, and other processes. The chemistry division to a large extent is working on customer problems, mainly in the area of protecting steel from corrosion. The division is engaged in exhaustive tests and studies, constantly searching for improved coatings for such widely different uses as containers and automobile bodies.

The main interests of the physics division centre on electronics, radiation gauging, and special measurements and controls. Bethlehem was a pioneer in the field of spectrographic analysis, which is typical of the work of the division. Other areas of work are in developing and assessing recording equipment and detection devices, including X-ray units. Though basically devoted to applied mathematics, stress analysis, and similar areas, the mechanics division also

## THE AMERICAN SCENE *(Continued)*



**300 lb experimental melt of steel being poured from an induction furnace in the process metallurgy pilot plant**

does work in proof-testing of a wide variety of products and applications, including strength data on welds. Work is also done in assessing the value of computers to various projects of the laboratories.

A technical library and a staff of trained technical information people make available a wide variety of periodicals and books, including translations from foreign sources. This library works closely with the Schwab Library in the company's main office, and also with the library of Lehigh University. The services division oversees the maintenance and construction of research equipment and facilities, and maintains a warehouse, a drawing office, and shops for designing and producing all kinds of special equipment.

### Administration Building

This main building is " U "-shaped, although a wing extends at right angles to each of the legs. In general, each wing provides three floors of offices or bench laboratories. The base of the " U," 133ft long and 45ft wide, accommodates the large entrance lobby, with offices above. The left leg of the " U," 131ft long and 43ft wide, houses the executive and technical offices, while the right leg, 315ft long and 66ft wide, is occupied by laboratories. A 136ft long, 43ft wide wing perpendicular to the laboratories affords additional office space for research personnel. The fifth wing is a two-storey cafeteria wing and extends at right angles from the base of the left leg of the " U."

All floors in the office areas are of cellular steel decking surfaced with slag concrete. Where heavier loads prevail, as in the laboratories, solid concrete slabs are used. All corridors are on the centre-lines of the wings, and the one in the laboratory wing is lined on either side with enclosed vertical wells through which all piped and wired services are brought to the laboratories, which occupy all three floors. A penthouse on the roof of the laboratory wing is entirely given over to mechanical equipment. Slightly set back from the lower portion of the building, this penthouse is enclosed with insulated steel panel walls and is windowless. To soften the somewhat severe appearance of these walls, in contrast to the windowed walls with limestone spandrels of the lower stories, the architect masked them with a decorative steel grille. The appearance of the building is further enhanced by a roof with wide eaves whose edges are scalloped in large-radius curves. Plastic bubbles spaced along the centre-line of this roof admit daylight to this enclosed third floor.

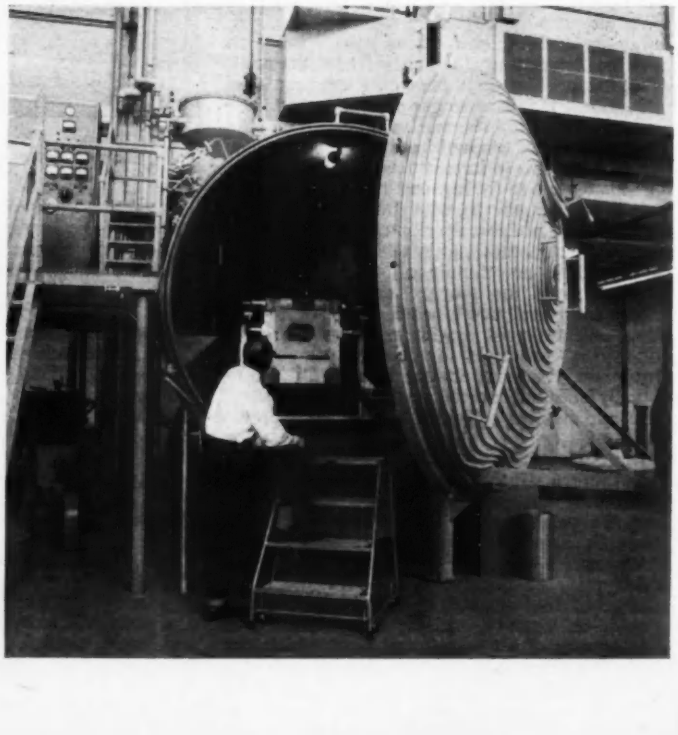
The other distinctive feature of this main building is a six-storey octagonal tower housing a technical library, and a lounge on the top floor. The tower and two-storey cafeteria wing are both located at the base of the left leg of the " U." In the two-storey cafeteria wing, the ground floor is open to permit passage of the research site circumferential road. The dining accommodations are on the second floor. This second floor is carried across the driveway by two welded girders 83ft long, built up of a 60in by 1½in web plate and 22in by 3in flange plates. Each girder weighs 35 tons and is continuous over three supports. The girders are spaced 45ft apart and support 75ft long floor beams of 36in 150 lb wide-flange sections. Both these long floor beams and the 35-ton girders were brought to the job in single pieces and were erected by using a large crawler crane. All of this steel framing is left exposed and painted black. Long spans are also used in the roof framing while the walls of the cafeteria section are almost entirely made of tinted glass in panes 7ft 6in wide and 19ft high.

This main building contains offices for executives, engineers and the clerical staff, as well as laboratories for five research divisions :

1. *Physics Laboratories.*—In the field of spectrography, six complete laboratories each contains its own power supply and necessary auxiliary equipment. Included are prism and grating spectrographs, which utilise photographic and direct reading methods of detection. There is also an installation for work in the vacuum ultraviolet region and an X-ray fluorescence laboratory. The instrumentation and controls laboratories are equipped for the design, development and testing of instrumentation for mill controls. The equipment primarily comprises electrical and electronic instrumentation. Other laboratories in this group are for the development of ultrasonic testing techniques, temperature measurement and non-destructive testing methods.

2. *Physical Metallurgy Laboratories.*—In the area of mechanical testing, the major equipment, in addition to the usual hardness testing and sample preparation equipment, includes a 100,000 lb universal testing machine, two 10,000 lb tensile machines, a 30-ton drawing press, an impact machine and a high-speed, rotating-beam fatigue machine. A creep test laboratory accommodates ten machines and auxiliary recording instruments.

In the metallography section, an X-ray diffractometer is used for the identification of unknown compounds in crystalline material ; auxiliaries are bench equipment for preparation and an X-ray film processing room. An electron microscope and auxiliary vacuum evaporation unit allows magnifications up to × 200,000 in metallurgical investigation. An electron microprobe analyser is used for quantitative analysis of minute volumes of material of the order of a cubic micron. An internal friction apparatus and equipment for measuring electrical resistivity are used in fundamental studies of metals to detect small amounts of carbon and nitrogen—down to 0·0001 per cent—in solution in iron. Also available are the usual grinding, polishing and etching equipment for metallographic sample preparation. Metallurgical microscopes permit examination of metal structures at magnifications up to × 2000. Other equipment produces black-and-white and colour photo-



**500 lb vacuum induction melting furnace for the production of steels with highest purity**

micrographs. Installed in the gas-metal reactions laboratory are small atmosphere-controlled tube and box furnaces for elevated temperature studies in this field, such as chromising, denitriding and decarburising. Equipment for metal preparation and enamel coating studies includes bench-scale pickling and nickel flashing baths, a spray coating booth, a drying oven and firing furnace. The necessary apparatus to determine enamel adherence and resistance to fish-scaling is also available.

**Experimental disc pelletiser for the formation of agglomerates for processing into blast furnace feed**

3. *Chemistry Laboratories.*—In the analytical sample preparation area, the equipment includes crushers, a pulveriser, a jar mill, a pneumatic mortar and pestle and small machine tools for the preparation of steel, ore and slag samples. The analytical laboratories have the usual analytical equipment, such as spectrophotometers, polarographs, induction furnaces for carbon and sulphur determination, coulometers for measuring electrical quantities, pH meters for measuring acid-alkaline content, and micro-analytical balances. In the surface chemistry section a film stripping unit permits stripping non-metallic films preparatory to studying their properties. An electron diffraction unit determines the composition and structure of very thin surface films. An " Ortholux " microscope is equipped for the examination of steel surfaces and their behaviour under solutions and at high temperature, as well as for colour microphotography. A Brunauer-Emmet-Teller unit is provided for measuring exact surface area. For surface behaviour study of metallic and other surfaces under various conditions, there is small highly specialised equipment, including an isolator laboratory to produce inert atmospheres for surface study and both analytical and micro-balances.

The high-temperature oxidation laboratory is equipped with a three-zone vertical tube furnace for producing various kinds of metal and oxide coatings and for studying oxidation. An analytical thermo-balance has the instrumentation and control for programming and recording heating, cooling and hold cycles with weight continuously recorded. A quartz fibre microbalance is capable of weighing layers of adsorbed material as thin as one molecule thick. Other facilities are standard muffle and crucible furnaces for atmosphere corrosion studies.

The surface treatment laboratory is equipped to try out rust preventives, such as slushing oils and white coatings, utilising a roller coater which handles sheets up to 24in wide. An environmental test cabinet for the full range of programmed environmental conditions handles up to one ton of 24in by 24in sheet. Other equipment includes a spectrophotometer, a pH meter and a drying oven. Because of its size and character, a Holden sodium hydride descaler with auxiliary bench and rinsing facilities has been installed in the pilot plant building nearby. This unit is used for removing rust and millscale from test material.

4. *Ceramics Laboratories.*—Here, the major equipment includes an X-ray diffraction and fluorescence unit and petrographic microscopes for the identification of mineral constituents of agglomerated ores, refractories and slags. In addition, there are areas for specimen preparation, containing a 20in diamond saw, crushers, grinders, polishers and vacuum impregnating equipment, and high-temperature programmed atmosphere-controlled tube furnaces.

5. *Chemical Engineering Laboratories.*—In the project development and ore treatment laboratory, studies of chemical engineering problems are made with special apparatus. Typical equipment includes small rotary kilns for studying reactions between solids and hot gases, special apparatus for the measurement of surface areas of powders, and apparatus for automatic analysis of blast furnace and coke oven effluents for phenol and cyanide. Another area is equipped with specialised bench-scale coal testing equipment for measuring fundamental properties during the coking process.

There are four protected autoclave installations, shielded by high-tensile steel plate, in a pressure laboratory for leaching experiments, primarily on ores, at temperatures above 212 deg. Fah. The grinding and furnace room is equipped for the preparation of materials for analysis. There are pulverisers, pelletisers, a flotation unit, drying ovens and calcining furnaces. In the fuels engineering laboratory there is an inert transfer chamber for the grinding, weighing and beneficiation of " H-Iron " samples. Other equipment includes crushers, sieves, microscopes, and balances for specimen preparation and bench scale apparatus for fuel analysis and testing.

**Experimental heat treatment facilities with various furnaces and a two-high/four-high combination rolling mill**

In the lubricants area there is testing and research equipment for oils and greases, including several types of lubricosity testers, bomb oxidation testers, a spectrophotometer, an apparatus for micro carbon-hydrogen determination and one for nitrogen determination, a calorimeter, and macro- and micro-balances.

A coal and coke chemicals by-product research projects laboratory utilises a spectrophotometer and a floor-mounted centrifuge in addition to the usual chemical bench equipment and glassware. The distillation-piloting laboratory is equipped with a complete range of rough and precise analytical distillation equipment. Glassware apparatus is used for flexible plant counterpart stills in the study of chemical piloting operations.

In the instrumental analysis section there are gas chromatographs used both for method research and applied analytical work, infra-red spectroscopes and mass spectrometry units for analysis of extremely complex chemical mixtures in conjunction with computer systems, and special-purpose electronic titration systems. The pollution control laboratory is used for the study of characteristic plant waste effluents and stream samples utilising standard analytical techniques.

The offices on any corridor of the main building are typical of all office arrangements. The rooms are laid out on the basis of 5ft by 15ft modules with movable steel partitions. An office for a senior staff member, for example, consists of three modules, or is a room 15ft by 15ft. There is a three-module conference room for each research division. A supervisor occupies two modules, or 10ft by 15ft. Clerical people have several different office arrangements ; for example, a four-module set-up for three people. Engineers are assigned to three modules, or 15ft by 15ft, based on double occupancy. The movable steel partitions permit overnight changes in floor layout, should the need arise.

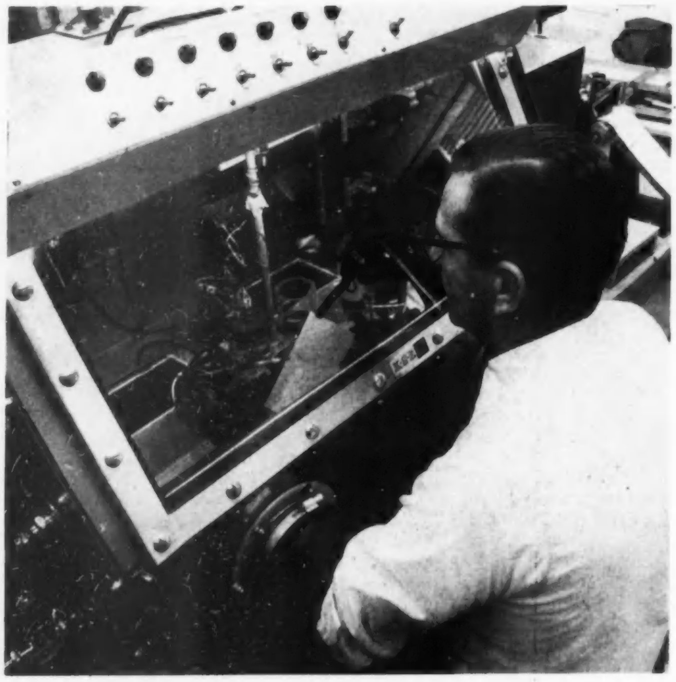
The bench laboratories are built on 10ft modules. Each laboratory has a service enclosure, with a chain for a safety shower. Even the smallest module has two emergency exits. Normally a single 10ft module is occupied by only one man. The service cupboard for each laboratory supplies special gases, fluids and electrical energy. Depending upon the needs of the particular laboratory, these services are tapped off as required. All utilities feed down from the top. Wide doors to the laboratory modules enable heavy, wide objects to be moved in and out.

### Shops and Warehouse Building

The most unusual building of the research complex is occupied by a warehouse on its ground floor and machine shops on its first floor, with additional laboratories. Its roof is unusual, in that its 245ft length is spanned by eleven 96ft long welded steel pipe trusses, 12ft deep at the centre and 6ft deep at the ends. In combination with the bracing used between them, these trusses constitute unique space frames that are stiff and strong yet give a light and open appearance to the interior of the building.

The space framing in each 20ft bay between trusses is made up of inclined pipe struts ; their lower ends are attached at the bottom chord panel points of the truss while their upper ends are joined to arch-shaped structural members disposed along the centre-line of the bay. The lengths of these arch-shaped members progressively diminish from the wall line to the centre-line of the building, so that in total they constitute a section of a cone with its apex at the

## THE AMERICAN SCENE *(Continued)*



Controlled atmosphere glovebox for research on the complex surface chemistry of tin-plate

building centre-line. To complete the bay framing, inclined structural members span between the arched members and the top chords of the trusses. The resulting roof, therefore, has a ridge outline over the trusses and an arch shape along the centre of each bay.

There are two drainage valleys in each bay where the ridge and arch roof elements intersect. These valleys diverge from the centre of the building outward because of the conical shape of the arch portion of the roof. The roof is covered with copper sheeting on steel decking, except where it is interrupted by skylights. The 96ft span trusses are fabricated from 5in diameter heavy-duty steel pipe. Each truss weighs $5\frac{1}{2}$ tons. Rigid when braced, the trusses were unusually limber as erection pieces. Steel channels, therefore, had to be lashed along their webs and chords during erection.

The shops and warehouse building contains a large area for storage, shipping and receiving, stocking and handling supplies, and a fully equipped machine shop with the necessary machine tools for the production of items required for both experimental and pilot plant operations. The drawing office of the service division designs and details special research equipment that cannot be purchased. This building also houses the following laboratories :

1. *Mechanics Laboratories.*—The major equipment in this area includes 300,000 lb and 60,000 lb universal testing machines, a 60,000 lb fatigue testing machine and a horizontal static and dynamic tension apparatus. In the field of welding, the facilities installed cover the full range of manual arc and gas welding equipment, flash welders, a spot welder and console-controlled submerged arc units mounted on a ram-type fixture. Auxiliaries include a stress-relief furnace and a powered welding positioner.

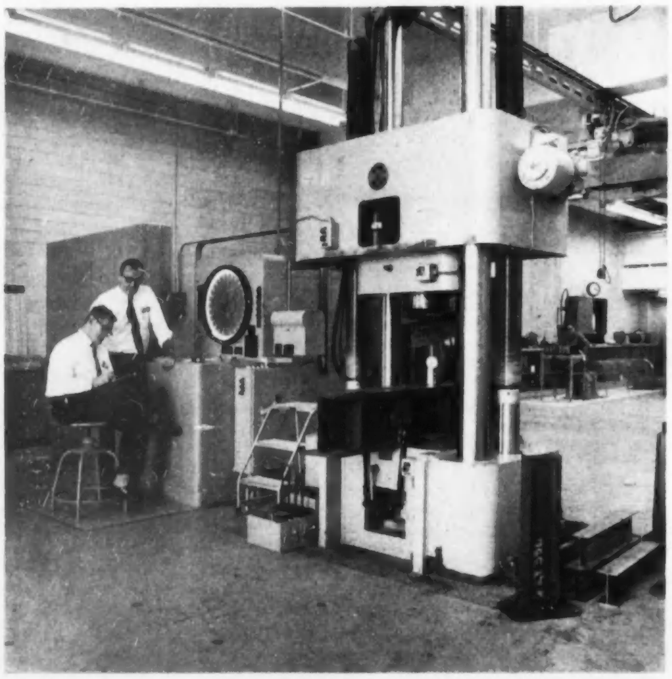
2. *Machinability Laboratory.*—In this section the major units are two multiple-spindle automatic screw machines capable of high spindle speeds for the utilisation of carbide tools, and a high-speed single-spindle centre lathe for machinability and tool life studies.

3. *Physical Metallurgy.*—This complete heat treatment laboratory has box furnaces covering the full heat-treatment temperature range for steel alloys, the necessary endothermic, exothermic and ammonia generators for atmosphere control, instrumentation for programming work, recording and temperature controls as needed, salt bath furnaces, a carbon-nitriding furnace and auxiliary quenching, cleaning and bench equipment. A small $1\frac{1}{2}$in and 5in by 8in two-high four-high combination rolling mill for hot and cold rolling studies is also installed.

### PILOT PLANT BUILDING

This building is laid out in a three-finger plan, each finger or wing housing a different research division on a single high-bay floor. All are linked across the front by a two-storey office and laboratory section. The office and bench laboratory space is comparable to that in the main building. The wing that is now completed —for the process metallurgy division—is 56ft wide in the high-bay area, 215ft long and 45ft high from the floor to the underside of the roof trusses. An overhead crane spans between girders, bracketed to the wall columns. The columns are exposed on the outside of the building where they form a part of the wall pattern, which includes limestone panels and top-hung, steel casement windows. Four flat-topped monitors on the roof provide for additional ventilation. The other wings—for the electro-mechanical division and the mechanical engineering division—are still under construction and essentially will be duplicates of the process metallurgy wing.

In the process metallurgy pilot plant area there is a 3-ton arc furnace, capable of melting 5-ton heats, air induction furnaces including 100 lb, 300 lb and 650 lb units, a 500 lb vacuum induction furnace installation and a 10kW ultrasonic unit for high-frequency vibration of steel ingots during solidification. Also planned are a hot rolling mill with auxiliary furnace equipment, and a consumable electrode furnace with a capacity up to 30in ingots. The auxiliary equipment includes a hood and dust collector for the arc furnace, a drying oven, scales up to 10,000 lb capacity, a 15-ton overhead crane with a 3-ton auxiliary hoist, a 750 lb forging hammer with the necessary furnaces, a blast cleaning unit and small machine tools, such as saws, a drill press, an abrasive cut-off machine, a pedestal grinder and an abrasive belt machine.



Destructive testing of a structural shape on a universal testing machine in the mechanics laboratory

## High-Speed Computer Relay

An extremely fast relay for which a life of over 200 million operations is claimed is now being marketed by the Line Electric Division of the Industrial Timer Corporation for many computer and data handling applications where solid state switching is normally used. This dry reed relay operates in the millisecond range and was developed by Line Electric after the Bell Telephone Laboratories, who had patented the switch in 1938, licensed certain manufacturers two years ago to use it in relays. Hitherto, all dry reed switches were manufactured by the telephone company for its own dialling systems. (See Plessey example, page 138, Jan. 23, 1959). Computers and similar data processing equipment make up the bulk of the requirement for dry reed relays, together with military needs arising in guidance systems employing low-level fast switching circuits. It is said that in a computer an equivalent number of switching diodes would require considerably more area than the corresponding dry reed relay. This is not because of the size of the diode, but because of the wiring required for its installation. Although switching diodes operate faster, in nanoseconds, more space and more wiring are required, and considerably more heat is generated. The Line Electric Company has available dry reed relays with up to twelve reeds as standard, in a variety of packages—plug-in, printed circuit, or with solder lugs.

# BRITISH PATENT SPECIFICATIONS

*The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 4s. 6d. each*

## METALLURGY

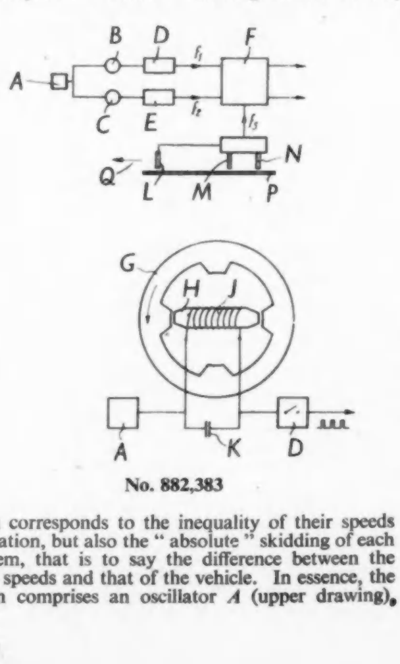
**881,792.** September 1, 1959.—COATING STEEL WITH ALUMINIUM, National Research Corporation, 70, Memorial Drive, Cambridge, Massachusetts, U.S.A. (*Inventors: Philip James Clough and Paul Lovett Raymond.*)

This invention relates to an improved process for providing thick, corrosion-resistant coating of aluminium on high-tensile-strength steel members, i.e., steel members having a tensile strength in excess of 200,000 lb per square inch. An improved high-tensile-strength steel product having a corrosion-resistant coating, the steel product being free of hydrogen embrittlement, is obtained. Recently alloys have been developed which demonstrate extremely high-tensile strength upon suitable heat treating. An example of such an alloy is "Vascojet 1000" (0·40 per cent C, 5·00 per cent Cr, 1·30 per cent Mo, 0·50 per cent V, balance iron). It has been established that a thick corrosion-resistant coating of aluminium can be applied to such steels in a manner which completely protects the steel against oxidation at elevated temperatures on the order of 800 deg. Fah.—1000 deg. Fah. and also protects the steel against atmospheric corrosion due to sodium chloride spray in the atmosphere. This is accomplished by vacuum depositing an aluminium coating after the steel surface has been heated to a temperature of from 700 deg. Fah. to 800 deg. Fah. At this elevated steel substrate temperature, the aluminium deposit has an equiaxed crystalline structure rather than a powdery or columnar structure. This temperature of preheating the steel substrate is below the tempering temperature of the steel and is sufficiently low so that no observable amount of diffusion of the aluminium into the steel takes place. Metallographic examination of aluminium-coated steel strips prepared in accordance with the invention have failed to show the presence of any measurable interdiffusion at the interface between the aluminium and the steel. Despite the lack of any discernable inter-metallic diffusion, the bond between the aluminium and steel is extremely strong. In fact, failure of the coating under bending occurs usually with rupture of the aluminium film or of the steel base rather than with rupture of the iron-aluminium bond. Additionally, the bond shows none of the brittleness encountered with iron-aluminium bonds formed at more elevated temperature where substantial interdiffusion of the aluminium with the iron base is encountered.—*November* 8, 1961.

## RAILWAY TRACTION

**882,383.** July 22, 1959.—DETECTING SKIDDING WHEELS IN RAILWAY VEHICLES, Forges et Ateliers de Constructions Electriques de Jeumont, 5, Place de Rio de Janeiro, Paris, France.

The present invention relates to systems for detecting the skidding of the driving wheels of railway vehicles. Its principal object is to signal very rapidly not only the "relative" skidding of the wheels, which corresponds to the inequality of their speeds of rotation, but also the "absolute" skidding of each of them, that is to say the difference between the wheel speeds and that of the vehicle. In essence, the system comprises an oscillator *A* (upper drawing), the output of which traverses several circuits in parallel, each circuit corresponding to one pair of driving wheels. Each circuit includes a modulating device, *B*, *C* and a two-state control device, *D*, *E*, which receives an oscillation modulated with an amplitude proportional to the speed of axle concerned and emits pulses with corresponding repetition frequencies. Thus two frequencies, $f_1$ and $f_2$ are applied to the comparator *F*. A third frequency, $f_5$ representing the vehicle speed is also fed into the comparator. A form of modulator is shown in the lower diagram. It may comprise a toothed rotary crown *G* of magnetic material, which revolves with the corresponding axle around a fixed armature formed by a magnetic core *H* carrying a fixed coil *J* connected to a condenser *K*. Rotation of the crown *G* modulates periodically the impedance of the coil *J*, as well as the tuning of the circuit *J*, *K*; consequently the current which is furnished by the oscillator to the two-state device presents a correspondingly modulated amplitude. The actual speed of the vehicle may be measured by a magnetic device which may comprise, for example, several magnetic members *L*, *M*, *N*, carried by the vehicle, which members co-operate with a rail *P* of the track when travelling in the direction *Q*. An emitter member *L* records on the rail "magnetic spots" which produce induced currents in receivers *M* and *N*, after which the spots are erased by an effacing member, not shown. Each operation of the receiver is adapted to control the emitter, causing it to record a fresh magnetic spot whereby the frequency $f_5$ of the pulsations which are received from *N* by the comparator, is proportional to the actual speed of the vehicle. The comparator *F* is responsive to the received frequencies of pulsations; it is adapted to compare the various frequencies $f_1$, $f_2$ with one another, and also to compare each of them with the frequency $f_5$. The first comparisons bring out the "relative" skiddings of the various wheels; the second ones bring out their "absolute" skiddings, that is to say the slippings of the various wheels in relation to the actual speed of the vehicle.—*November* 15, 1961.

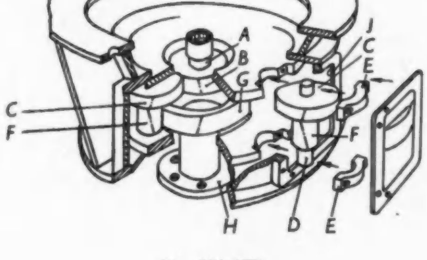


No. 882,383

## POWER TRANSMISSION

**881,970.** June 2, 1960.—GEARBOXES, David Brown Industries Ltd., Meltham Mills, Meltham, Huddersfield, Yorks. (*Inventor: Norman Waterworth.*)

The invention relates to gearboxes having co-axial input and output shafts and at least one layshaft on which are fixed two gears adapted to mesh respectively with a gear on the input shaft and a gear on the output shaft. The object of the invention is to enable gears to be removed from the box without disturbing the machinery connected to the input and output shafts.



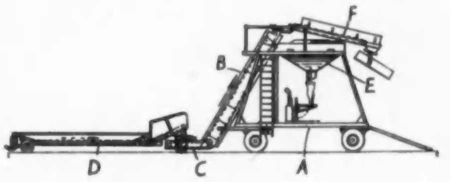
No. 881,970

The accompanying drawing is a diagrammatic perspective view of a vertical, co-axial double reduction gearbox. This gearbox has a fabricated casing provided with upper and lower flanges for the attachment, respectively, of an electric driving motor and a driven machine. The output shaft of the motor is connected to an input shaft *A* and on the inner end of this shaft there is fixed a helical pinion *B*. The input shaft and pinion are not mounted in bearings, but the pinion is centralised by meshing with three helical gears *C* fixed on respective layshafts *D* which are equally spaced about the axis of the pinion. Each of the layshafts is mounted in bearings (not shown) secured by caps *E*, and a helical pinion *F* is formed integral with each layshaft. The three pinions *F* mesh with, and centralise, a helical gear *G* connected to an output shaft *H* by a gear type coupling (not shown). The output shaft is connected to the driven machinery. The axial thrusts produced by the running in mesh of the single helical gears are taken by thrust cones of known type secured to the respective layshafts. Oil is continuously circulated through the gearbox, and oil seals are provided between the casing and the input and output shafts. Three apertures *J* formed in the casing adjacent the layshafts, are provided with cover and each is large enough to permit the removal of the adjacent layshaft and of the pinion *B* and gear *G*. The layshafts are rendered removable by detaching the bearing caps, and the pinion *B* and gear *G* are removable due to the provision of the gear couplings.—*November* 8, 1961.

## MECHANICAL HANDLING

**881,864.** January 6, 1958.—CONVEYING APPARATUS FOR COAL AND BULK MATERIALS, Peter Charles Duffield Moy, Merryhill, Chappell, Near Colchester, Essex (formerly of Countess Cross House, Colne Engaine, Colchester, Essex).

The invention provides conveying and elevating apparatus, particularly for use in the discharging of bulk carrying wagons. In illustrated example the apparatus a wheeled vehicle with a chassis *A* has an upright framework which supports an elevating conveyor. This conveyor has an inclined portion *B* which, at its lower end, is continued in a horizontal extension *C* mounted on a short frame with road wheels. The conveyor is an endless belt fitted with spaced flights and driven by side chains. Combined with the vehicle carrying the elevating conveyor is a wheeled trailer *D* which is articulated to the conveyor frame. The trailer provides a mounting for a feed belt conveyor and discharges on to the elevating conveyor. The elevating conveyor discharges material at the top in either of two ways. Material may be allowed to fall into a hopper *E* from which it will flow to bag filling and weighing apparatus, or it may be conveyed on to an endless belt conveyor *F* for bulk discharge. When the discharge is taken through the hopper a screen may be inserted to channel dust away from the bag filling outlets.—*November* 8, 1961.



No. 881,864

## ELECTRICAL ENGINEERING

**882,330.** April 24, 1958.—ELECTRIC MOTORS, T.M.M. (Research) Ltd., Hartford Works, Oldham, Lancashire. (*Inventor: Joseph France.*)

This invention relates to an improved electric motor which is particularly but not exclusively suitable for use in driving machinery such as textile speed frames, which must be brought smoothly from a standing start to full speed. According to the invention the motor has a multi-phase rotor winding and a stator having two cores axially adjacent and forming a slidable unit. One of these cores carries a cage winding, but the other is blank. When the stator is positioned so that substantially no current is induced in the cage winding by the rotating field produced in the energised rotor winding, the rotor remains stationary. If the stator is then moved axially so that the cage enters the magnetic field, a progressively increasing torque is applied to the energised rotor, which starts to revolve, the torque reaching a maximum when the cage completely embraces the rotor. To allow sliding movement, the stator is mounted in a housing carrying an external rib or key which works in internal grooves in the motor casing. Slide rods attached to the stator extend through guides through the end of the casing and are connected to a plate adapted for coupling to a manual or servo control. By fine adjustment of the stator position, the speed frame driven by the motor may be inched under close control, and since the rotor is continuously energised, this operation causes no arcing at electrical contacts.—*November* 15, 1961.

## British Standards Institution

*All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.*

### SCHEDULE OF COPPER ALLOY INGOTS AND COPPER AND COPPER ALLOY CASTINGS

No. 1400 : 1961. Price 20s. This schedule was first issued in 1948 when the numerous individual British Standards for copper alloy ingots and castings were withdrawn and their requirements included in one volume. Among the many changes in a new edition just issued is the inclusion of a colour code for each of the ingots specified. It was not possible, unfortunately, to extend this scheme to include castings. High conductivity coppers HCC1 and HCC2 and new alloys PB4, LB4, LB5, G3, SCB4, SCB5, CMA1, CMA2, and DCB3 have now been included. Three of these arise from an extension of the range of brasses previously designated " B ", and its sub-division into sand cast brasses (designated " SCB ") and die cast brasses (designated " DCB "). For convenience the earlier superseded code numbers are included in the summary table. One alloy, SB1, has been omitted. A number of amendments have been made to the chemical compositions of the alloys, including differentiation between the limits specified for ingots and castings for certain of the elements. Mechanical properties have also been reviewed and a number of amendments made. Throughout,reference is made to " permanent set stress " instead of " proof stress " as the former is the test used with copper base casting alloys and is now defined in B.S. 18, " Tensile Testing of Metals." For the phosphor bronzes, leaded bronzes and gunmetals, properties for continuously cast material have been included. The general format of the schedule and the wording of general and specific clauses have been brought into line as far as possible with the recommendations of PD 2436, " Memorandum on the Preparation of British Standards for Non-Ferrous Metals." For the gunmetals and leaded gunmetals recent research on the effect of impurities has been taken into account in fixing limits only for those elements known to be harmful and likely to be present, and a total figure has not been included.

### REVISED BRITISH STANDARD SPECIFICATION FOR pH SCALE

No. 1647 : 1961. Price 4s. 6d. The use of pH as a measure of acidity and alkalinity has long been familiar in science and industry. Originally, pH was intended to denote $-\log_{10} C_H$, where $C_H$ is the hydrogen ion concentration, but it is now realized that this quantity is not measurable. In fact, if pH is to be a measurable quantity it cannot have any exact simple fundamental significance. It is therefore necessary to define pH in terms of the method of measurement, and since more than one definition is possible on this basis there is need for a standard pH scale.

In B.S. 1647, which was first published in 1950 as a result of an initiative by the Royal Society, the plan adopted is to define the difference in pH between two solutions in terms of a specified electrometric measurement and to complete the definition by assigning a value of pH at each temperature to one chosen solution, termed the primary standard. The definition applies to aqueous solutions within certain limits of temperature, and is intended to ensure that, when different workers refer to a stated measured value of pH, they mean the same thing within ±0·005. Within this degree of accuracy there is no practical difference between the British Standard pH scale and the scale adopted by the National Bureau of Standards (U.S.A.), although the latter specifies four standard solutions instead of one. The primary standard specified in B.S. 1647 is a 0·05 molar solution of potassium hydrogen phthalate.

No basic change has been made in revising the British Standard, but its usefulness has been increased by extending the range of temperature covered. Originally 0 to 60 deg. Cent. this range is now 0 to 95 deg. Cent. Corresponding extensions have been made to the relevant tables in the Appendices.

As in the previous edition, recommendations for the use and calibration of the glass electrode are included, together with information on the pH values of aqueous solutions suitable for this purpose. It has not been found possible to make more than one addition to the list of these solutions, the pH values of which must be known reliably to an accuracy of ± 0·005, and the desirability of further additions is emphasized in the text.

### FITTINGS FOR CYLINDER PRESSURE INDICATORS FOR RECIPROATING ENGINES

No. 412 : 1961. Price 4s. Two additional metric sizes on diagram sheet have been added to this revised publication which specifies the requirements for the fittings of cylinder pressure indicators on slow and medium speed reciprocating engines. In addition to the 6½in by 3in, and the 5in by 2¼in sizes, the standard also includes the 145mm by 65mm, and the 115mm by 45mm sizes, both of which are in general use throughout industry.

A change has also been made in the type of screw thread connecting the indicator valve or cock to the cylinder and indicator. For the cylinder connection, the BSW thread has been replaced by a Unified thread to B.S. 1580. The B.S. pipe thread for the indicator valve has been replaced by a metric size thread of Whitworth form which has been adopted in accordance with current British and Continental practices. Also included in the standard are requirements for the limits of accuracy of the indicator reducing gear.

### CORROSION—RESISTING STEEL SPLIT COTTER PINS FOR AIRCRAFT

No. 90 : 1961. Price 3s. This standard specifies the materials, dimensions, finish and identification of the pins, and follows the now generally accepted convention of defining the nominal length of the pin as the distance from the underside of the eye to the end of the short leg. B.S. SP 9, dealing with nickel alloy pins, will be made obsolete as a result of the new standard.

## Catalogues and Brochures

Decca Radar Ltd., Albert Embankment, London, S.E.1.—Folder giving brief specifications of the seven complementary weather and windfinding radars of the Decca seeries.

Griffin and George (Sales) Ltd., Chromatography Division, Ealing Road, Alperton, Wembley, Middx.—A twenty-page brochure printed in English, French and German, describing the " D6 " gas density balance chromatograph.

E.M.I. Electronics Ltd., Hayes, Middx.—Illustrated leaflet describing the " EMIAC " 2 analogue computer and giving examples of typical problems to which it may be applied in automobile, chemical, structural and aeronautical engineering.

Cambridge Instrument Company Ltd., 13, Grosvenor Place, London, S.W.1.—List No. 281/2 describing magnetic oxygen meters which have been developed for the determination of oxygen concentrations using methods based on the high paramagnetic susceptibility of the gas.

Ames Crosta Mills and Co. Ltd., Moss Iron Works, Heywood, Lancashire.—Book entitled " The Simplex High Tensity Aeration Process for Sewage Purification." It contains eighty-four pages of detailed technical information, together with basic design data and illustrations.

Hadfields Ltd., East Hecla Works, Sheffield.—Publication No. 466.S.—containing the current British and American (A.S.T.M. and S.A.E.) Standard Specifications for steel castings. Some European and Swedish castings specifications similar to the carbon steel specifications of B.S. 3100 are included.

James Booth Aluminium Ltd., Kitts Green, Birmingham, 33.—A six-page folder containing details of the standard architectural aluminium sections produced by the company, including comprehensive details and section silhouettes of James Booth Aluminium continuous facing system, handrails, thresholds, sills and edge fascias.

Electrical Development Association, 2, Savoy Hill, London, W.C.2.—" Electricity and the Influence of Light upon Poultry Husbandry," by S. A. Fox. A paper read at the E.D.A. Rural Electrification Conference, 1961, at the University of Nottingham School of Agriculture, and " Electricity and Sortage Brooders for Poultry Rearing," by E. C. Claydon and G. P. Print.

Siemens and Halske Aktiengesellschaft, (United Kingdom Distributor, R. H. Cole (Overseas) Ltd., 2, Caxton Street, Westminster, London, S.W.1.)—Leaflet describing " BY 242 " silicon rectifier. Electrically the rectifier is said to be identical with the company's " OY 241," but the mechanical arrangement has been altered to make it suitable for use with printed circuit wiring.

The Ruberoid Company Ltd., Commonwealth House, 1-19, New Oxford Street, London, W.C.1.—A new " Built-up Roofing Catalogue." It is divided into three sections, the first containing general information. The second section is devoted to the many firms of substructure and other factors influencing the choice of built-up roofing at the design stage, and the third section gives details of " recommended and economy " Ruberoid specifications, and incorporates three specification selection guides for flat roofs, pitched roofs, and curved and free-shaped roofs.

Distillers Plastics Group, Devonshire House, Piccadilly, London, W.1.—Illustrated booklet surveying the history of the group, its present extent and ramifications. British Resin Products Ltd., Distrene Ltd., and British Geon Ltd.—the three companies which now comprise the Distillers Plastics Group—manufacture a comprehensive range of synthetic resins, platics materials and nitrile rubbers. The Group's factories are at Barry, Glamorgan, where they share a 200 acre site and some 1800 people are employed. Annual output exceeds 100,000 tons. Materials produced in the factories at Barry are marketed under the trade marks " Cellobond," " Cellomold," " Epok," " Rockite," " Styron," " Distrene," " Geon," " Hycar," and " Breon." The Group also markets " Rigidex," a polythene based on the process development by Phillips Petroleum Company of the U.S.A.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the* TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*Thurs., Dec.* 28.—Northern Ireland Centre : Central Hall, Rosemary Street, Belfast, Film, " See It Now—Automation." 7.30 p.m.

### BRITISH INSTITUTION OF RADIO ENGINEERS

*Wed., Jan.* 3, 1962.—London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Symposium on " Data Transmission," 10 a.m.

### ILLUMINATING ENGINEERING SOCIETY

*Wed., Jan* 3, 1962.—Swansea Group : Demonstration Theatre, South Wales Electricity Board, The Kingsway, Swansea, " Floodlighting for Industrial Situations," A. E. Fothergill, 6 p.m.

*Thurs., Jan.* 4, 1962.—Nottingham Centre : Electricity Centre, Carrington Street, Nottingham, " Lighting for Crime Detection," C. H. Edlin, 6 p.m.

### INSTITUTE OF METALS

*Thurs., Jan.* 4, 1962.—London Local Section : 17, Belgrave Square, London, S.W.1, " New Methods of Powder Generation," K. M. Spring, 6.30 p.m.

### INSTITUTE OF PETROLEUM

*Wed., Jan.* 3, 1962.—61, New Cavendish Street, London, W.1, " The Economics of Tanker Design," I. B. Blackwood, 5.30 p.m.

### INSTITUTE OF REFRIGERATION

*Thurs., Jan.* 4, 1962.—Institute of Marine Engineers, Memorial Building, 76, Mark Lane, London, E.C.3, " Refrigeration in Dam Cooling," S. I. Neuman, 5.30 p.m.

### INSTITUTE OF WELDING

*Thurs., Jan.* 4, 1962.—Christmas Lecture for Young People : 54, Princes Gate, Exhibition Road, South Kensington, London, S.W.7, " Joining the Modern Way," John Strong, 11 a.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*Tues., Jan.* 2, 1962.—North Midland Centre : Leeds and County Conservative Club, South Parade, Leeds, 1, " Progress in Oil-Filled Cables and their Accessories," A. N. Arman, F. J. Miranda and G. R. Bishop, 6.30 p.m. ★ South Midland Centre : Town Hall, Birmingham, Faraday Lecture, " Expanding Horizons in Communications," D. A. Barron, 7 p.m.

*Wed., Jan.* 3, 1962.—Tees-side Sub-Centre : Cleveland Scientific and Technical Institution, Middlesbrough, " The Application of Electrical Technology to Instruments in the Chemical Industry," J. C. Quayle, 6.30 p.m. ★ Southern Centre : The University, Southampton, " Short-Circuit Ratings for Main Cables," G. S. Buckingham, and " A Basis for Short-Circuit Ratings for Paper-Insulated Cables up to 11kV," L. Gosland and R. G. Parr, 7 p.m.

*Thurs., Jan.* 4, 1962.—Ordinary Meeting : Savoy Place, London, W.C.2, " The Transmission of Power at High Voltages," F. J. Lane, 5.30 p.m. ★ North Staffordshire Sub-Centre : Victoria Hall, Hanley, Faraday Lecture, " Expanding Horizons in Communications," D. A. Barron, 7 p.m.

*Fri., Jan.* 5, 1962.—Medical Electronics Discussion Group : Savoy Place, London, W.C.2, Discussion on " Membranes," opened by H. Davson, 6 p.m.

### INSTITUTION OF HEATING AND VENTILATING ENGINEERS

*Tues., Jan* 2, 1962.—South Western Branch : R. W. A. School of Architecture, Bristol, " The Application of Pneumatic Controls to Air Conditioning with Special Reference to High Velocity Air Conditioning," G. F. Brown, 6.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*Tues., Jan* 2, 1962.—Coventry A.D. Centre : Grosvenor Room, Hotel Leofric, Coventry, " The Agricultural Tractor—Its Function and Design," W. J. Foxwell, 7.15 p.m.

*Wed., Jan.* 3, 1962.—Western A.D. Centre : Royal Hotel, Bristol, Informal Meeting, 7 p.m. ★ Lubrication and Wear Group : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on " Wear of Rubbing Electrical Contacts," 6 p.m.

*Thurs., Jan.* 4, 1962.—Eastern Branch : Sun Hotel, Hitchin, Herts., " Powder Metallurgy Applications," B. H. Swan, 7.30 p.m. ★ Midland Branch : James Watt Memorial Institute, Great Charles Street, Birmingham, Repetition of the James Clayton Lecture, " Machine Tool Research, Design and Utilisation," D. F. Galloway, 6 p.m.

*Fri., Jan.* 5, 1962.—North Western Branch · The University, Manchester, Repetition of the Leonardo da Vinci Lecture, " The Challenge of Vertical Take-Off," : Part I—" Helicopters," G. S. Hislop, and Part II—" Jet Lift," D. Keith-Lucas, 2.30 p.m.

### INSTITUTION OF PLANT ENGINEERS

*Tues., Jan.* 2, 1962.—Peterborough Branch : White Lion Hotel, Church Street, Peterborough, " Rocket Propulsion and Control," D. Hurden, 7.30 p.m.

*Wed., Jan.* 3, 1962.—Leicester Branch : Grand Hotel, Leicester, " Safety of an Electrical Installation," F. Noakes, 7.30 p.m. ★ Southern Branch : Polygon Hotel, Southampton, Forum on " Engineering Education and Training," 7.30 p.m.

*Thurs., Jan.* 4, 1962.—Birmingham Branch : Hotel Leofric, Coventry, Open Forum, 7.30 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*Wed., Jan.* 3, 1962—Midlands Region : Wolverhampton and Staffs. College of Technology, Wolverhampton, " Recent Developments in Automatic and Semi-Automatic Welding," L. H. Morgan, 7.15 p.m.

### INSTITUTION OF STRUCTURAL ENGINEERS

*Fri., Jan.* 5, 1962.—Midland Counties Graduates' and Students' Section : Engineering Centre, Birmingham, " Elevated Roadways," G. B. Smedley, 6.30 p.m. ★ Western Counties Branch : Queen's Building, University Walk, Bristol, " A Mobile Tower for Servicing Rockets," F. K. Fennell, 6 p.m. ★ South Western Counties Section : Duke of Cornwall Hotel, Plymouth, " Aluminium Structures with Particular Reference to Bridges," R. M. Davis, 6 p.m.

### JUNIOR INSTITUTION OF ENGINEERS

*Fri., Dec.* 29.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " The Turn of the Century : A Pictorial Survey," J. Foster Petree, 7 p.m.

### NEWCOMEN SOCIETY

*Wed., Jan.* 3, 1962.—Lecture Theatre, Science Museum, South Kensington, London, S.W.7, " William Wood and the Coke-Smelting Process," M. W. Flinn, 5.30 p.m.

### PLASTICS INSTITUTE

*Thurs., Dec.* 28.—Midlands Section, Reinforced Plastics Group : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, " Survey of New Developments in Resin," H. R. Everard, 7 p.m.

*Tues., Jan.* 2, 1962.—Midlands Section : Grand Hotel, Leicester, " Education in the Rubber and Plastics Industries," F. H. Cotton, 6.45 p.m.

*Wed., Jan* 3, 1962.—North-Eastern Section : Eldon Grill, Eldon Buildings, Grey Street, Newcastle upon Tyne, 1, " Foamed UF Resins and Expanded Plastics," W. Massingham, 7 p.m.

*Fri., Jan* 5, 1962.—Young People's Lecture : Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, " Nature's Plastics," M. Stacey, 2.30 p.m.

### ROYAL INSTITUTION OF CHARTERED SURVEYORS

*Tues. and Wed., Jan.* 2 *and* 3, 1962.—Christmas Holiday Lectures and Exhibition : 12, Great George Street, London, S.W.1, " Map-making To-day," W. A. Seymour and D. L. Griffith, Lectures, 10.30 a.m. and 2.30 p.m. Exhibition, 9.30 a.m. to 5 p.m.

### SOCIETY OF INSTRUMENT TECHNOLOGY

*Wed., Jan.* 3, 1962.—South Yorkshire Section : Brown-Firth Research Laboratories, Princess Street, Sheffield, 4, Films, 7 p.m.

*Fri., Jan.* 5, 1962.—Fawley Section : Room 4a, Administration Building, Esso Petroleum Company Ltd., Fawley, " Measurement of Flow," J. Singer, 5.45 p.m.